FISCAL YEAR 1983 DEPARTMENT OF ENERGY BUDGET REVIEW

(Conservation and Renewable Energy)

HEARINGS

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

SECOND SESSION

MARCH 9, 11, 16, 17, 1982

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CONTENTS

WITNESSES

	Page
March 9, 1982:	
Hon. Larry Winn, Jr., a Member of Congress from the State of Kansas	16
Joseph Tribble, Assistant Secretary for Conservation and Renewable Energy, Department of Energy; accompanied by: Mel Chiogioji, director, State and local programs; Robert San Martin, Deputy Assistant Secretary for Renewables; Maxine Savitz, Deputy Secretary for Conservation; and James Sterns, Director, Office of Alcohol Fuels	18
March 11, 1982:	
Henri-Claude Bailly, president, Hagler-Bailly & Co	75
Robert Lawrence, director, technical development, Mechanical Technology, Inc., accompanied by Robert S. Kripowicz, program development manager, Mechanical Technology, Inc	91
William Kirsch, director, center for energy management and economical development, University City Science Center	108
Donald F. Jorczak, product manager, energy recovery department, Dresser Industries, Inc.; accompanied by Ardon B. Judd, Jr., staff vice president and Washington counsel, Dresser Industries, Inc	138
Deborah Bleviss, Energy Conservation Coalition	155
Ellis Bullock, vice president, American Institute of Architects	177
Clair Ames, president, Ames Building Corp., Evansdale, Iowa	200
Ralph J. Johnson, president, research foundation, National Association of Home Builders	203
March 16, 1982:	
Byron Washom, president, Advanco Corp	232
Harold E. Seielstad, energy research department, Pacific Gas and Electric Co	280
Elliot Berman, Arco Solar, Inc.; accompanied by George Tenet, director, photovoltaic and international programs, Solar Energy Industries Association	291
Jerry Birchfield, director, technology applications laboratory, engineering experiment station, Georgia Institute of Technology	313
Bradford M. Mead, director, energy programs, Grumman International, Inc	329
Drs. Aden B. Meinel and Majorie P. Meinel, University of Arizona	339
Myron Nordquist, legal counsel, Ocean Energy Council	353
March 17, 1982:	
Truman Anderson, director, program planning and analysis, Oak Ridge National Laboratory, Oak Ridge, Tenn	377
Dr. Eric Hirst, Oak Ridge National Laboratory, Oak Ridge, Tenn	388
Milton Copulos, policy analyst, Heritage Foundation, Washington, D.C	437
Ronald S. Wishart, director, energy and transportation policy, Union Carbide Corp., New York, N.Y	445
Arthur Jackson, director, wind energy programs, Hamilton Standard, Winsor Locks, Conn	467
Dan DiGiovacchino, manager, wind energy programs, General Electric Co., King of Prussia, Pa	486
Robert G. Lacy, manager, heber binary project, San Diego Gas and Electric Co., San Diego, Calif	502
Lawrence S. Germain, deputy associate director, alternate energy sources, Los Alamos Scientific Laboratory, Los Alamos, N. Mex	514

APPENDIXES

	Page
Appendix I—Questions and answers submitted by DOE for the record	536
Appendix II—Additional material submitted by DOE for the record	701
Appendix III—Additional material submitted by members and witnesses for the record:	
ORNL Report	874
Douglas Harvey paper	944
AIA, David D. Meeker, letter and paper	989
NCAT, David J. Hoffman, statement	1001
Ralph J. Johnson, letter	1012
Willett Kempton, letter and papers	1015
J. C. Grosskreuz, letter and paper	1069
John D. Reichert, statement	1091
SEIA, R. Nicholas Loope, statement	1096
Dr. Elliot Berman, letter and questionnaire	1009
EPRI, Dr. Edgar DeMeo, letter and statement	1130
EPRI, Journal, December 1981, "Earth's Renewable Resources	1145
Technecon, Thomas A. V. Cassel, letter and statement	1221
Bendix, E. Z. Gray, letter	1233
Elinor Schwartz, State of California, statement	1235
Solarex Corp., Joseph Lindmayer, statement	1242

1983 DEPARTMENT OF ENERGY AUTHORIZATION

TUESDAY, MARCH 9, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to recess, at 11:05 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, White, Wolpe, Winn, Fish, Gregg, Sensenbrenner, Skeen, McGrath, Lowery, Schneider, and Weber.

Staff present: Martha Krebs, counsel; and Daniel M. Steinway, minority counsel.

Mr. FUQUA. The subcommittee will be in order. This morning the subcommittee holds its first of four hearings on the DOE fiscal year 1983 authorization request for conservation and solar energy. Our witness today is Mr. Joseph J. Tribble, the Assistant Secretary for those programs at DOE.

The administration has presented us with essentially a closeout budget for energy conservation in fiscal year 1983. It has requested no funding for buildings, industrial or transportation research, or any of the programs we are accustomed to authorizing in this subcommittee.

After a year of assurances that the private sector will pick up the activities being terminated by the Federal Government, we have seen little evidence that that is true. With high interest rates, soft world oil prices, and a general recession, business appears less inclined to make those investments than it did last year. Although we strongly hope for an economic recovery, it would be imprudent to make drastic and sudden changes in our energy programs based on that hope.

The DOE sunset review, in its detailed discussions, confirms what the subcommittee has known all along: the conservation R.D. & D. programs are effective, beneficial programs which have produced useful results that would not be obtained without Federal support.

A report published last year by Oak Ridge National Laboratory, which I would like to submit for the record, indicates that conser-

vation programs will reduce primary energy consumption by 12 quads in the year 2000, a savings of oil worth more than $100 billion.

[The report mentioned above is included in Appendix III. The executive summary follows:]

ORNL/TM-7690/V1

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OAK RIDGE NATIONAL LABORATORY

UNION CARBIDE

OPERATED BY UNION CARBIDE CORPORATION FOR THE UNITED STATES DEPARTMENT OF ENERGY

Energy Saving Impacts of DOE's Conservation and Solar Programs

(An ORNL/MITRE Study Performed in 1980)

Volume 1
Executive Summary and Analysis Overview

ORNL/TM-7690/V1

Contract No. W-7405-eng-26

ENERGY DIVISION

ENERGY SAVING IMPACTS OF DOE's CONSERVATION AND SOLAR PROGRAMS

(An ORNL/MITRE Study Performed in 1980)

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Volume 1 — Executive Summary and Analysis Overview

Manuscript completed: April 6, 1981

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ABSTRACT

The ORNL/MITRE study was commissioned to assess the energy-saving (displacing) and oil-saving impacts of the Department of Energy's conservation and solar programs. Although it was a coordinated modeling and analysis exercise that employed ORNL's existing computer models of energy use and MITRE's computer models for assessment of solar technology penetrations, it also involved an important participation by the planning staff and the program office representatives of Conservation and Solar Energy, the Department of Energy.

The ORNL/MITRE team analyzed most, but not all, of the DOE's conservation and solar programs. Energy and oil impacts were estimated under a common set of assumptions concerning rising energy prices and economic growth. This report documents the analysis performed and the results obtained.

The study results show that the impacts of analyzed programs are very significant and rise over time. In the year 2000, for example, the analyzed programs are estimated to reduce primary energy consumption by 11%, increase solar use by 36%, and reduce the combined fossil and nuclear use by 16% from the baseline projection that explicitly excluded these programs.

More significantly, the analysis showed that the oil savings are high. For example, at $40/barrel the present value of estimated oil savings for the 1980-2000 period is over $200 billion when discounted at a real rate of 3% per year and over $110 billion when discounted at a real rate of 8% per year.

Recognizing that many recipients may not be interested in all the details of the material presented and to achieve cost-effective distribution, this report is being issued in two volumes:

Volume I: Executive Summary and Analysis Overview (about 60 pages)

Volume II: Historical Trends, Details of Sectoral Analysis, and Appendixes (about 600 pages)

Volume I is self-contained and covers the entire study. It is expected that many readers will find it sufficient for their use. Those more closely involved in the subject matter as well as those interested in pursuing the details of the study may wish to obtain a copy of Volume II.

1. EXECUTIVE SUMMARY

The ORNL/MITRE study was commissioned to assess the energy-saving (displacing) and oil-saving impacts of the Department of Energy's conservation and solar programs. Although it consisted primarily of a coordinated modeling and analysis effort of a team of ORNL/MITRE analysts, it also involved an important participation by the planning staff and the program office representatives of Conservation and Solar Energy, the Department of Energy.

A significant feature of the study is that the energy and oil impacts of the federal programs were estimated within the context of a baseline (reference) detailed set of energy-use and solar technology penetration projections. These projections were developed with ORNL's computer models of energy use and MITRE's computer models for assessment of solar technology penetrations. The models were operated under a common set of assumptions concerning rising energy prices and economic growth.

The ORNL/MITRE team analyzed most, but not all, of DOE's conservation and solar programs. The study results show that the impacts of analyzed programs are very significant and rise over time. In the year 2000, for example, the analyzed programs are estimated to reduce the primary energy consumption by 11%, increase the solar use by 36%, and reduce the combined fossil and nuclear use by 16% from the baseline projection.

More significantly, the analysis showed that the oil savings are high. For example, at $40/barrel the present value of estimated oil savings over the 1980-2000 period is over $200 billion when discounted at a real rate of 3% per year and over $110 billion when discounted at a real rate of 8% per year.

Aggregate energy impacts of analyzed sectoral and cross-sectoral programs are shown in Fig. 1.1. As given, the aggregate effect of the analyzed sectoral conservation and solar programs is:

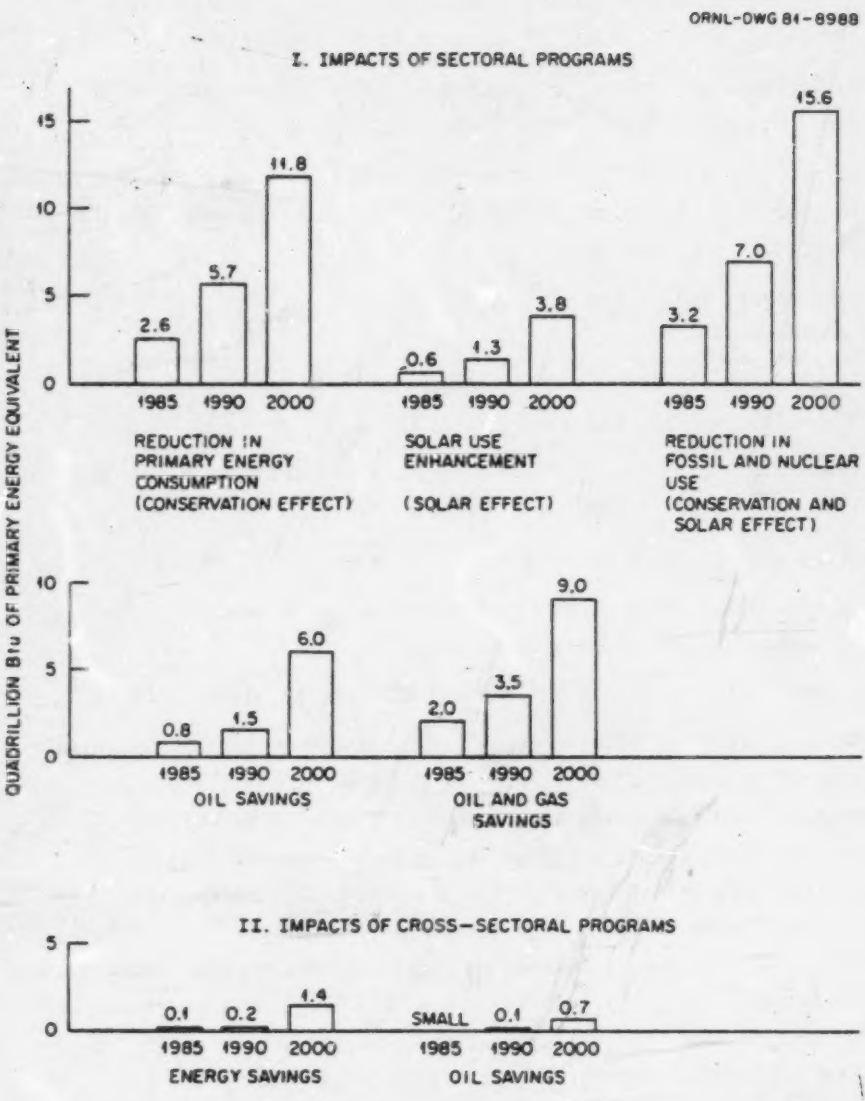

Fig. 1.1. Aggregate energy impacts of analyzed sectoral and cross-sectoral programs.

- to reduce the primary energy consumption by 2.6 quads in 1985, 5.7 quads in 1990, and 11.8 quads in 2000 (conservation effect);
- to increase the solar use by 0.6 quad in 1985, 1.3 quads in 1990, and 3.8 quads in 2000 (solar effect);
- to reduce the fossil and nuclear use by 3.2 quads in 1985, 7.0 quads in 1990, and 15.6 quads in 2000 (combined conservation and solar effect).

With regard to oil and gas savings, the ORNL/MITRE estimate is that these programs will:

- bring about oil savings in the amounts of 0.8 quad in 1985, 1.5 quads in 1990, and 6 quads in 2000;
- bring about oil and gas savings in the amounts of 2.0 quads in 1985, 3.5 quads in 1990, and 9.0 quads in 2000.

Separately, the analyzed cross-sectoral programs are estimated:

- to reduce the primary energy consumption by 0.1 quad in 1985, 0.2 quad in 1990, and 1.4 quads in 2000;
- to save 0.1 quad of oil in 1990 and 0.7 quad of oil in 2000.

The estimates and related details were developed by the ORNL/MITRE analysts, using scenario analyses. The baseline scenario included macroeconomic and fuel price assumptions of Table 1.1 as well as all legislation passed before December 31, 1979; but it specifically excluded all programs of Conservation and Solar (CS) Energy, the Department of Energy. The energy-use projections under the baseline scenario were developed using the ORNL/MITRE pooled computer model system; they are shown in Fig. 1.2. As indicated, the baseline energy use grows to 107 quads in 2000. Be definition, these projections include the effect of higher fuel prices and tax credits legislated prior to December 1980.

A second scenario, the program impact analysis scenario (PIAS), included not only the specifications of the baseline scenario but also all of the sectoral DOE/CS programs that were assessed. It too was

Table 1.1. Summary of baseline scenario macroeconomic and macroenergy specifications

Variable	Average annual growth rate (%)	
	1980-1985	1980-2000
• Economic		
- Real gross national product	3.2	2.8
- Real disposal income	3.0	2.8
- GNP deflator	8.2	6.9
• Demographic		
- Population	0.9	0.8
- Labor force	1.5	1.1
• Uninflated fuel prices		
- Oil products	4.4	2.0
- Electricity	1.1	0.6
(Other inputs: gas and coal prices, detailed industrial production levels, etc.)		

analyzed using the ORNL/MITRE pooled computer model system. The resulting energy-use projections are shown in Fig. 1.3. The differences between the two projections characterize the estimated impacts of analyzed sectoral programs of the DOE/CS organization.

Due to time constraints, the effects of cross-sectoral programs of community systems and energy storage systems were estimated but not integrated in the above scenario analyses. Their energy and oil impacts are therefore separately shown in Fig. 1.1. Because of the overlapping nature of their impacts, while the joint effect of analyzed sectoral and cross-sectoral programs would be larger than the effects of the sectoral programs, the joint effect also would probably be smaller than the sum of the effects of the sectoral and cross-sectoral programs.

Moreover, due to resource constraints, no estimates were developed for the following programs: urban waste, energy extension service, state energy conservation program, emergency energy conservation, energy conversion and utilization, appropriate technology small grants, and energy-related inventions program.

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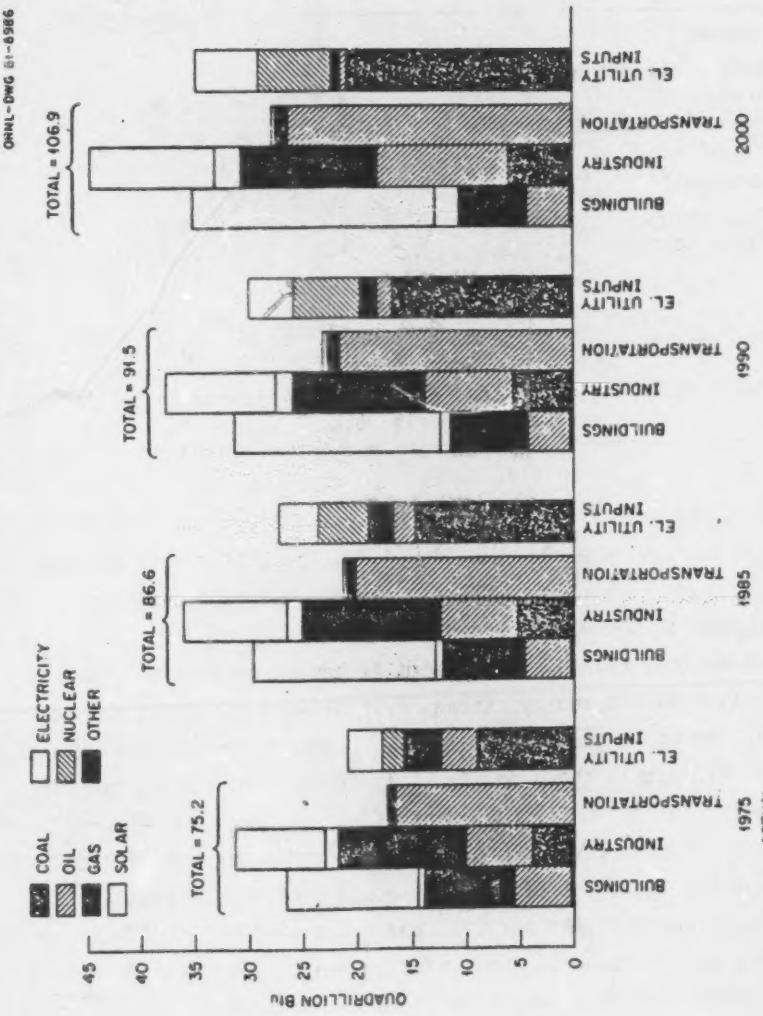

Fig. 1.2. Baseline energy-use projections (quadrillion Btu primary energy equivalent).

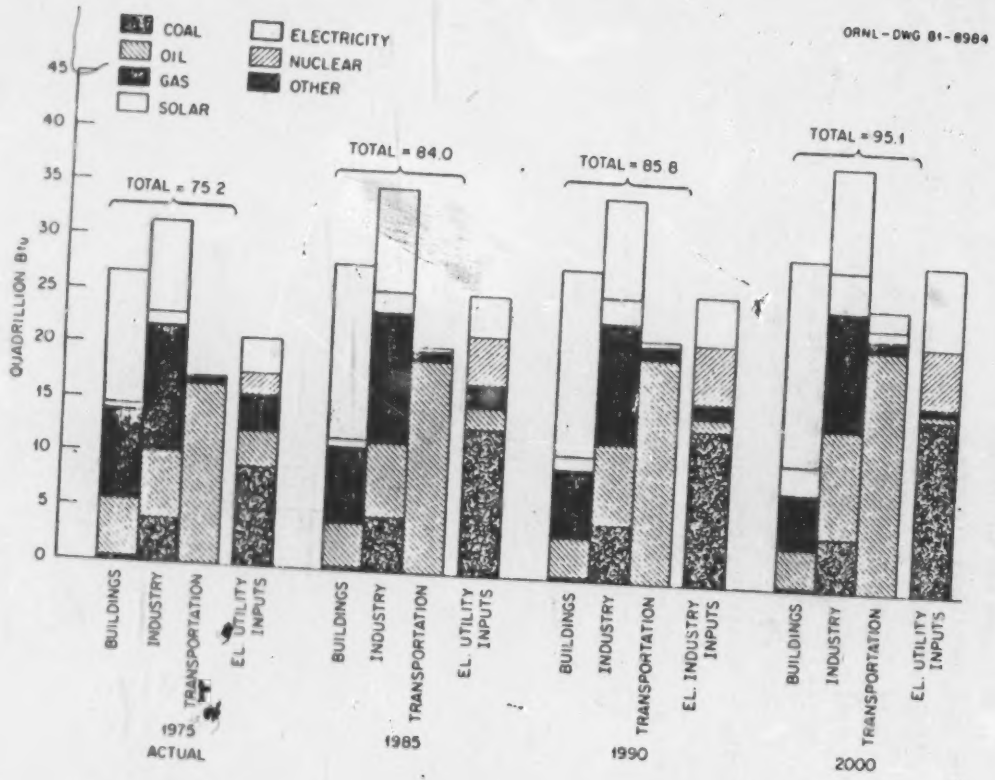

Fig. 1.3. Energy-use projections under the program impact analysis scenario (quadrillion Btu primary energy equivalent).

1-7

This study establishes that an integrated assessment of conservation and solar programs can be performed. Such an approach represents a major step forward in the methodology for assessment of the DOE/CS program portfolio (or even the entire DOE portfolio) in comparison with the previously used individual program assessments. The details of the new ORNL/MITRE methodology do need to be more fully developed, however. Also, due to time and resource limitations, it was possible to develop only a single set of estimates. Thus it was not possible to explicitly treat the uncertainty in the estimates.

Details of the analysis, further implications of the overall results, and study caveats are presented in Sect. 2. Also, documentation of sectoral details may be found in Sects. 4 through 9. Appendixes contain additional details.

(Figures 1.4 and 1.5 provide numerical information for Figs. 1.2 and 1.3, respectively.)

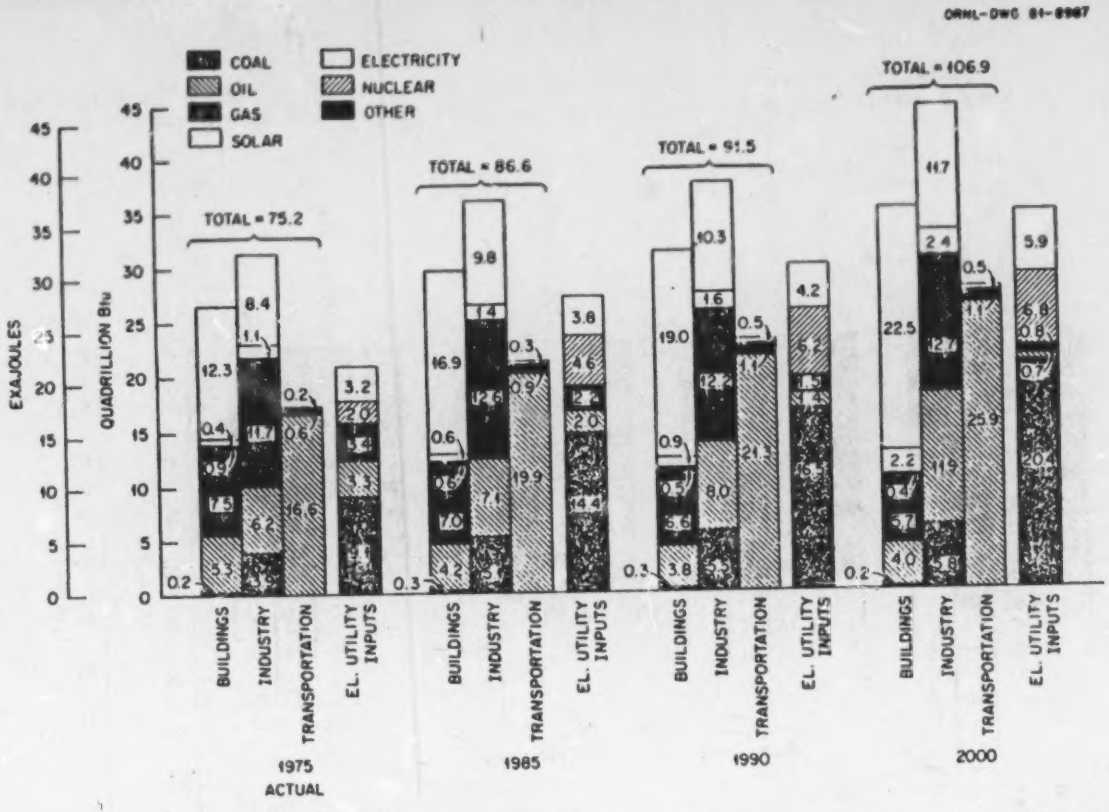

Fig. 1.4. Baseline energy-use projections (1×10^{15} Btu primary energy equivalent). (This figure provides numerical information for Fig. 1.2.)

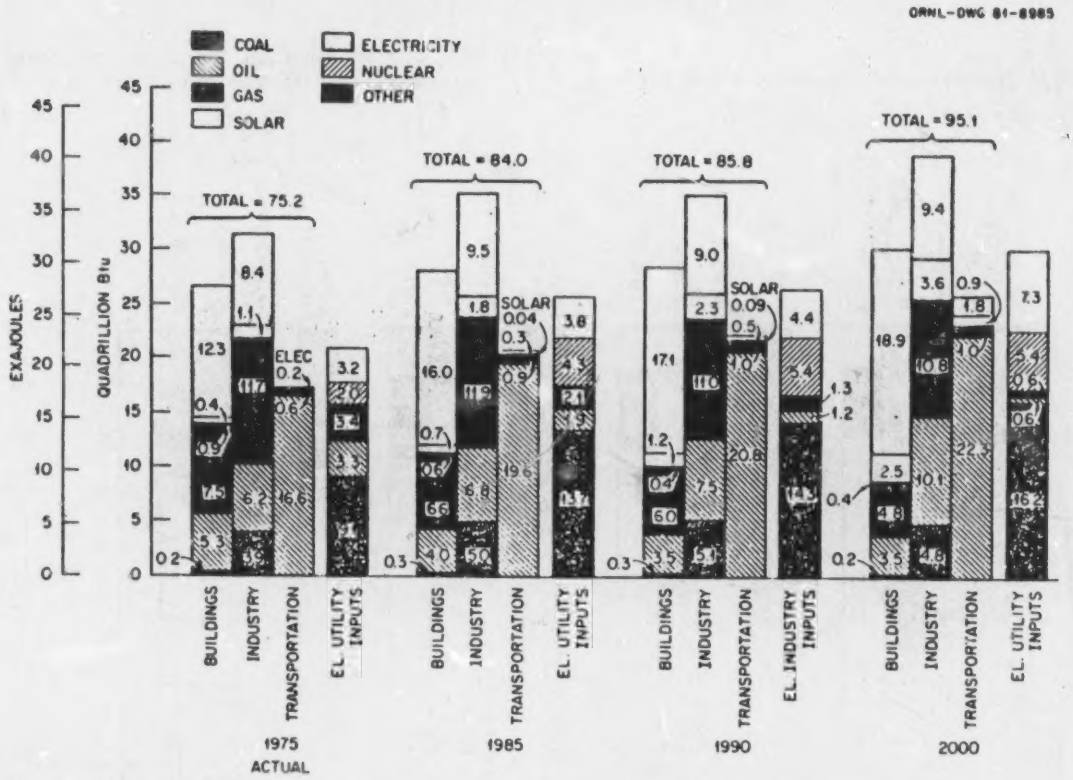

Fig. 1.5. Energy-use projections under the program impact analysis scenario (1×10^{15} Btu of primary energy equivalent). (This figure provides numerical information for Fig. 1.3.)

Mr. FUQUA. Despite this, it appears that DOE is cutting even basic and applied conservation research activities. Work on building envelopes, ventilation, indoor air quality, materials and thermal transfer all long-term basic research is being cut by more than 80 percent.

It also appears that the threat of foreign competition from industry-government teams selling energy efficient technologies may be more significant than we realized last year. Work done by two consulting teams for DOE and by the subcommittee staff indicates that the Europeans and the Japanese are definitely directing near-term energy technology development activities toward the American market.

In solar, we are presented with a larger, but equally inadequate request. The Department of Energy, in cooperation with Congress, has spent more than $3 billion over the past 7 years on solar energy R.D. & D. Many of the technologies being pursued are just entering the development phase where systems are being built and tested in the field. The programs have created a number of impressive facilities and demonstrations which are just beginning to provide data and real-world experience. High quality research teams have been set up around the country at JPL, SERI, Sandia, NASA Lewis, and elsewhere.

The administration's fiscal year 1983 budget would scrap all of that, destroying the foundation upon which a viable solar industry could be created. Many development activities in wind, photovoltaics, solar thermal, OTEC, and biomass will be terminated prematurely, before industry has sufficient data and experience to pick them up. Much basic and applied long-term research is being eliminated. Test facilities such as the central receiver test facility at Sandia are being closed down. Demonstration projects such as the photovoltaic residential experiments are being dismantled or turned over to the private sector.

Finally, I am deeply concerned about the actions that are being taken by DOE right now that may effectively terminate solar and conservation activities in 1982. I refer specifically to projects like the solar thermal repowering design activity which was explicitly included in both the reconciliation and appropriations bills but has yet to be acted on by DOE. I refer to the letter received 2 weeks ago from Mr. Tribble which indicates that he allowed the conservation and solar programs to spend less than 20 percent of their alloted ceilings for the first 6 weeks of fiscal year 1982. I refer, finally, to the personnel ceilings provided in the 1983 budget books which indicate that more than two-thirds of the staff in conservation and half the staff in solar are likely to be RIF'd this year.

It appears that some officials in the Department of Energy are seeking to accomplish by administrative fiat what they were unable to achieve through the legislative process last year. I would remind them that authorization and appropriations bills are the law of the land which they are duty bound to obey.

Mr. Winn?

STATEMENT OF HON. LARRY WINN, JR., A MEMBER OF CONGRESS FROM THE STATE OF KANSAS

Mr. WINN. Thank you, Mr. Chairman. Today the Subcommittee on Energy Development and Applications begins its hearings on the conservation and the renewable energy portion of the energy budget. Our committee has heard a great deal about the promise of these two energy options. For example, in the conservation area, our committee heard just last week from the Energy Research Advisory Board about the need to maintain a serious conservation R. & D. program.

I think it is in our Nation's best interests to pursue the development of all of our promising energy options, including solar, geothermal, fossil, nuclear fission and fusion, hydropower, and increased conservation. A balanced approach will allow us to take advantage of the benefits of all of these resources. We cannot lose sight of the unlimited potential of solar energy, nor of the cost-advantages of conserving our precious petroleum supplies.

I urge the committee to seriously review the administration's budget request in conservation and renewable energy. I, for one, have been very proud of our committee's past record in analyzing solar energy and conservation budget requests. I think that the record will show that we have made good use of our limited Federal funds in light of our overall budget constraints. We must continue our tradition of setting priorities and of funding these areas which promise high potential payoffs. I hope that all of the members of the subcommittee will keep these goals in mind as we proceed to consider the fiscal year 1983 energy budget request.

However, I would like to raise for the committee's consideration, a DOE program which is not within this committee's jurisdiction, but which bears directly upon our concern with the significant reductions in the conservation and renewable resources R. & D. budgets. Under the Pacific Northwest Electric Power Planning and Conservation Act (Public Law 96-501), the Bonneville Power Administration is required to treat conservation and renewable resources as the region's highest priority resources, and is authorized to undertake a comprehensive regional program. Section 8(d)(3) of the act authorizes BPA to borrow up to $1.25 billion from the U.S. Treasury to create a revolving fund to implement this policy. We need to understand the effect that this program will have on the development of conservation and renewable resources technologies before we suggest increases in the same R. & D. programs under our jurisdiction. The BPA funding for next year alone is $444 million.

I would like to welcome Mr. Tribble, the Assistant Secretary for Conservation and Renewable Energy. We are most happy to have you come before the committee again, Mr. Tribble. We look forward to hearing your testimony on the Department of Energy's 1983 budget request in conservation and renewable energy.

Thank you again, Mr. Chairman, for allowing me to make these remarks, and I look forward to a most productive hearing.

[The opening statement of Mr. Fish follows:]

OPENING STATEMENT OF HON. HAMILTON FISH, JR.

Thank you, Mr. Chairman. Today we once again begin our hearings to consider a new energy budget. I look forward to working with you again, Mr. Chairman, this year in considering the Department of Energy's budget request for fiscal year 1983. We will be facing many severe budget constraints this year, but I am very confident that under your guidance, we will be able to fashion an effective energy research and development program for fiscal year 1983.

In addition, I would also like to welcome Mr. Tribble, the Assistant Secretary for Conservation and Renewable Energy, who is with us again today. Mr. Tribble has given us his expert testimony several times in the past, and I look forward to hearing his comments today on the fiscal year 1983 budget.

Unfortunately, I have several serious concerns about the energy budget which the Administration has sent us this year. As my colleagues are well aware, the Administration has called for dramatic cuts across the board in the conservation and renewable energy areas. Many programs which the Committee has supported in the past, such as industrial conservation and the various solar technologies, will be terminated if we accept the Administration's request.

This budget request is certainly at odds with many respected energy studies. Last week the Committee heard the findings of a study by the Energy Research Advisory Board on federal energy R&D priorities. I believe that these findings are most noteworthy. On an overall basis, the Board strongly indicated that energy conservation R&D was underfunded, particularly when compared with funding levels for energy supply technologies. A balanced energy budget that better reflects the opportunities and importance of all of our energy options, including energy conservation, should be achieved. I hope we can hear from the Department today on the extent to which the ERAB panel recommendations were taken into account in fashioning this year's budget request.

I do not think that our Nation can afford to be lulled into complacency by the present oil glut on the market. We must move forward with the development of promising new energy technologies, certainly taking into account our significant budget constraints. I would hope that our Subcommittee will seriously review the Administration's energy R&D recommendations and make sure that we are acting in a manner consistent with our overall energy goals.

Thank you again, Mr. Chairman, for allowing me to make these remarks. I look forward to hearing from the Assistant Secretary.

Mr. FUQUA. Without objection a statement by Mr. McCurdy will be placed into the record.

Without objection, photographs and recordings may be made during the proceedings today.

[The prepared statement of Mr. McCurdy follows:]

REPRESENTATIVE DAVE MCCURDY—EDA HEARINGS ON CONSERVATION AND RENEWABLES—Mar. 9, 1982

Mr. Chairman, I just want to say that I am very disappointed with the fiscal year 1983 Federal energy budget that the administration has proposed. It is both unbalanced and unsound. Conservation and renewable programs are a vital component of a responsible and effective national energy policy, yet the fiscal year 1983 budget request literally decimates these programs: The $22 million for conservation represents a 94-percent reduction from the fiscal year 1982 appropriation and a 97-percent cut from fiscal year 1981 levels; the $83 million for solar and other renewables is a 78-percent cut from fiscal year 1982 levels and an 87-percent reduction from fiscal year 1981 levels. Assuring a secure and independent energy future requires a balanced and consistent Federal energy budget and policy. Conservation and renewables must be included in that policy and I hope that all of us here will work to restore adequate funding to these vital energy programs.

Mr. FUQUA. Mr. Tribble, we are very happy to have you here today, and we anxiously await your testimony.

STATEMENT OF JOSEPH TRIBBLE, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY; ACCOMPANIED BY MEL CHIOGIOJI, DIRECTOR, STATE AND LOCAL PROGRAMS; ROBERT SAN MARTIN, DEPUTY ASSISTANT SECRETARY FOR RENEWABLES; MAXINE SAVITZ, DEPUTY SECRETARY FOR CONSERVATION; AND JAMES STERNS, DIRECTOR, OFFICE OF ALCOHOL FUELS

Mr. TRIBBLE. Thank you, Mr. Chairman and members of the committee. I appreciate the opportunity to appear before you today to discuss the authorization for the Department's conservation and renewable programs.

I would like to introduce the others with me here today because they constitute the key teams through which the programs are implemented. On my far left is Dr. Melvin Chiogioji who is Director of the Office of State and Local Programs. On my immediate left is Dr. Robert San Martin, Deputy Assistant for Renewable Energy. On my right is Dr. Maxine Savitz, Deputy Assistant for Conservation. On my far right is Mr. James G. Sterns who is the Director of the Office of Alcohol Fuels.

Mr. FUQUA. We are very happy to have all of you here. Many of you are no strangers to this committee.

Mr. TRIBBLE. I would like to have my complete testimony entered into the record, if I may, and give you a brief statement.

Mr. FUQUA. Yes. Without objection, your statement in its entirety will be made part of the record. If you wish to summarize——

Mr. TRIBBLE. If I may.

Mr. FUQUA.We would be pleased to hear from you.

Mr. TRIBBLE. Thank you.

Following the oil embargo of 1973, and until 1980, the United States faced a problem which was quite different from those we had faced in the past. Some thought that our sources of energy were being exhausted. We were becoming more and more dependent upon oil imported from the Middle East. While prices charged for this oil were escalating, most of the prices for domestically produced oil and natural gas were controlled at very low levels. Relatively inexpensive energy, one of the basic building blocks of our economy, was becoming a thing of the past.

Many people felt that this was a problem that the Federal Government could and should resolve, and there were vocal demands for attempts to do so. In response, Congress enacted a legislative program which was designed to force energy conservation and subsidize rapid development of energy from renewable sources.

Since the enactment of this legislation, billions of dollars have been spent on research, development, demonstration, and commercialization activities for the purpose of bringing into more widespread use energy from such sources as solar, geothermal, wind, biomass, ocean thermal, and alcohol fuels. The technology for using these sources of energy has been advanced to the point where their further development and use can now be implemented by the private sector whenever they become economical.

Today the energy situation does not appear as intractible as it appeared when these legislative programs were enacted. Importation of petroleum into the United States is down more than 50 per-

cent from its previous high. The price for imported petroleum is below its high. The price of domestically produced petroleum has been decontrolled, and the price of domestically produced natural gas has been permitted to rise manifold over the price at which it was controlled in 1972.

Comparing 1972 to 1980, the energy efficiency of the 10 most energy-intensive industries in the United States has improved by 17.6 percent. Comparing 1975 to 1981, the miles per gallon of fuel for new domestically produced automobiles has improved by more than 60 percent. Residential energy consumption per household is down almost 20 percent in 1980 compared to 1972. In every case, the cost of energy has been responsible for the great majority of these improvements.

It is, therefore, entirely appropriate that the role of the Federal Government with respect to energy be reevaluated.

Rather than continued emphasis on bringing alternate sources of energy into the marketplace through Federal Government subsidy, it is now more appropriate that the Federal program be limited to research of a more basic nature. If some of the remaining unknowns can be removed through research, the private sector will be able to hasten the day when energy from renewable sources will take a more prominent place in our economy.

Much of the money that this committee has authorized in the last few years has gone into hardware. Many of these installations are now in the data-collecting stage. As the chairman has reflected earlier, we do have some very impressive installations for all of the renewable resource technologies. Many of these installations are now in the data-collecting stage, and it is our intent to gain all the information which is useful from these demonstrations and package that information in a form where it will be useful to anyone who wants to use it.

Considering that every dollar we spend today is a dollar we must borrow at current high interest rates and add to the Federal deficit, we have proposed a very lean budget. However, we have tried to continue research which will provide the energy industry with a broader technological base.

Mr. Chairman, that concludes my summary statement, and we would be pleased to attempt to answer your questions and those of the other members of the committee.

[The prepared statement of Mr. Tribble follows:]

STATEMENT OF JOSEPH J. TRIBBLE

ASSISTANT SECRETARY

FOR

CONSERVATION AND RENEWABLE ENERGY

3/9/82

FY 1983 AUTHORIZATIONS

Mr. Chairman and Members of the Subcommittee:

I appreciate the opportunity to appear before you today to discuss the authorizations for the Department's conservation and renewable programs. The budget before you today reflects this Administration's commitment to the goals of the Economic Recovery Program, the need to minimize Government intervention in the marketplace, and the need to continue Federal support for research in areas where such support is appropriate.

Following the oil embargo of 1973, and until 1980, the notion was widespread that the United States faced a problem which was quite different from those we had faced in the past. Some thought that our sources of energy were being exhausted. We were becoming more and more dependent upon oil imported from the Middle East. While prices charged for this oil were escalating rapidly, most of the prices for domestically-produced oil and natural gas were controlled at very low levels. Relatively inexpensive energy, on of the basic building blocks of our economy, was becoming a thing of the past.

Many people felt that this was a problem that the Federal Government could and should resolve, and there were vocal demands for attempts to do so. In response, Congress enacted a legislative program which was designed to force energy conservation and subsidize rapid development of energy from renewable sources. Since the enactment of this legislation, billions of dollars have been spent on research, development, demonstration, and commercialization activities for the purpose of bringing into more widespread use energy from such sources as solar, geothermal, wind, biomass, ocean thermal and alcohol fuels. The technology for using these sources of energy has been advanced to the point where their further development and use can now be implemented by the private sector whenever they become economical.

Today the energy situation does not appear as intractible as it appeared when these legislative programs were enacted. Importation of petroleum into the United States is down approximately 50 percent from its previous high. The price for imported petroleum is below its high. The price of domestically produced

petroleum has been decontrolled and the price of domestically produced natural gas has been permitted to rise many fold over the price at which it was controlled in 1972. Comparing 1972 to 1980, the energy efficiency of the ten most energy-intensive industries in the United States has improved by 17.6 percent. Comparing 1975 to 1981, the miles per gallon of fuel for new domestically-produced automobiles has improved by more than 60 percent. Residential energy consumption per household is down almost 20 percent in 1980 compared to 1972. In every case, the cost of energy has been responsible for the great majority of the improvements.

More remarkably, very little of this very great change in circumstance was predicted by those who urged creation of massive Federal Energy programs. In retrospect, we wee that the total effect of all government action has been relatively minor. It is, therefore, entirely appropriate that the role of the Federal Government with respect to energy be re-evaluated.

Rather than continued emphasis on bringing alternate sources of energy into the marketplace through Federal Government subsidy, it is now more appropriate that the Federal program be limited to research of a more basic nature. If some of the remaining unknowns can be removed through research, the private sector will be able to hasten the day when energy from renewable sources will take a more prominent place in our economy.

Let me turn now to the specifics of the FY 1983 budget.

CONSERVATION

In the area of conservation, we will focus on expanding our scientific knowledge base by supporting generic high-risk, long-term research in selected technological areas. This new focus is reflected in the consolidation of our previous sector-oriented programs into a single Energy Conservation Research Program.

The basic objective of this program is to provide the technology base

and technology options that the private sector can utilize in the development of more efficient energy conservation equipment and utilization processes. This program will solidify the technology base used by the private sector in designing the developing processes and equipment in their application to the transportation, buildings and industrial energy-use sectors.

The FY 1983 request for Energy Conservation Research is $17.5 million, which includes $1.7 million for program direction. This request will fund research activities in four research areas: heat transfer and fluid mechanics, materials and processes, thermochemical conversion, electrochemical storage and conversion. Activities in each element focus on research topics having high potential for improving energy use efficiency.

Heat Transfer and Fluid Mechanics

The request for heat transfer and fluid mechanics is $3.2 million, which will support technology base activities underlying the design of heat exchangers, and fundamental studies of heat loss in structures and industrial equipment. Research will also focus on generic properties of fluids and fluid systems that affect the efficiency of operation of power systems such as advanced heat engines and heat pumps.

In FY 1983, heat exchanger activities will build on earlier efforts that resulted in an integrated, computerized data base and model system for the prediction of flow-induced vibration. Research will focus on the modeling mechanism of flow-induced vibration in shell-and-tube heat exchangers caused by two-phase (steam/water) flow, and on innovative concepts such as suspended particle and direct contact heat exchanger concepts.

Heat transfer research activities directed at structures will focus on wall and roof systems, windows and daylighting, computer modeling enhancements and estimating methods.

In wall and roof systems research, data collected from extensive test cell measurement will be used to analyze the effect of temperature set-back, and windows and doors will be analyzed to determine the effect on building mass. Dynamic performance research will complete analyses of moisture migration and condensation, thermal performance, and air/moisture transfer in wall sections using a calibrated hot box at the National Bureau of Standards.

Research on windows and daylighting will work with physical and computational models to continue development and cross-validation of predictive luminance, thermal, and energy consumption models for analysis of geometrically complex window design, sun control systems, and spaces and for variable filtering devices. Climatological studies will continue to support the effort on luminance availability. In the area of performance, studies on mobile daylighting and thermal test cells will be completed. Validation tests in the field will be initiated on natural illumination, net through-fenestration energy flow measurement, and net room energy-use impact. Estimating methods will focus on the greatest common denominator to complete transient heat transfer, fluid flow, and mechanical systems response modeling in the DOE-2 computer simulation program.

Materials and Processes

The major thrust in materials research will be directed toward high temperature structural ceramics. While major advancements have been achieved in shape, fabrication and material strengths of structural ceramics, e.g., advanced gas turbine rotors have been cold spun to 126 percent and 134 percent of design speed with no failure, significant technological advances are needed in order for heat engines to operate more efficiently in severe environments.

Funding of $2.99 million will be directed at advanced materials development and processing, advanced net-shape materials fabrication, and new approaches to

assuring structural integrity of advanced materials. Research would also be carried out on evaluation of critical properties of newly developed materials and determination of the interrelationship between newly developed processes, associated microstructure, and properties.

Several projects will be devoted to advanced materials development of: high-temperature ceramic/ceramic composites, ceramic matrix/metal fiber reinforced composites, a new family of transformation-toughened ceramics, and new thermal barrier materials. The goal is to develop composites that are low in cost and have low thermal expansion and conductivity coefficients. These materials will be able to withstand high temperatures, have moderate to high strength, and have high fracture toughness. Property evaluations will be made of friction and wear of ceramics and metals for high load environments. Newly developed ceramics will be subjected to screening tests, including thermal fatigue to examine their time-temperature-stress behavior. Promising candidate materials (fabricated in realistic shapes) will be tested in realistic environmental exposures.

Other materials research activities will focus on indoor air quality and gas isotope enrichment. In the indoor air quality research, work will be performed on minimum air changes to determine transport phenomena (spatial distribution). The analysis of potential control techniques will be completed. This will build on earlier advancements including development of a simplified device that would allow large scale measurement of air infiltration of buildings to be made at 1-2% of the cost of current techniques.

Chemical process research initiated in FY 1982 to study the biocatalyzed production of bulk chemicals, such as nitrogen fertilizer and ethylene feedstock, will be continued. Emphasis will be on techniques to preserve the catalytic activity and increase the lifetime of enzyme catalysts under projected reaction conditions.

Thermochemical Energy Conversion

The objectives of the thermochemical energy conversion are to develop accurate and reliable methods for industry use in designing components for more efficient internal combustion engines and methods for use in designing more efficient commercial and industrial furnaces. Advances have been made in addressing such technological barriers as our current incomplete understanding of engine and furnace combustion phenomena and lack of technology base. Since 1981, DOE has successfully adopted laser-based instruments to measure phenomena in internal combustion engines and developed computer models to analyze intake, fuel preparation, and exhaust processes in internal combustion engines.

FY 1983 funding of $2.37 million will support improved design and analysis capabilities for operation at reduced fuel-air ratios. Engine cycles to be included are direct-injection stratified charge (DISC) and dilute homogeneous charge (DHC).

In FY 1983, research on high-efficiency energy-conversion equipment/home heating equipment will continue to develop the fundamental understanding of thermodynamic properties, the kinetic properties, and materials/fabrications associated with the coupling of small heat engines to freon compressors. Planned milestones for FY 1982 will result in the development and testing of a dynamic coupling/seal for novel engine freon compressor systems. Successful coupling techniques could lead to industry's development of gas-fired, engine-driven residential heat pumps, capable of operating at double the efficiency of standard electric air/air heat pumps. Work will also be completed on the analysis of novel materials and material designs that could be utilized in the design of heat exchangers for use in residential-sized, condensing-mode heating systems. This work includes analyzing condensate composition of the waste gas stream of conventional heat exchangers.

Electrochemical Storage and Conversion

The objective of the electrochemical storage and conversion activities will be directed at the fundamental understanding of thermodynamics, kinetics, electrocatalysis, mass transport, and materials synthesis and fabrication as they relate to batteries and electrochemical processes and energy conversion. Anticipated milestones for FY 1982 will result in an advanced alternating current propulsion system for an electric vehicle that permits a 50 percent reduction in cost and weight over existing systems. Industry may find many ultimate uses for the results of this research in the development of new technologies such as batteries in automobile propulsion, utility, and residential load leveling.

The FY 1983 request of $7.22 million will fund research on new active and passive cell materials for rechargeable cells offering much higher performances and cycle life at reasonable costs, generic problems of existing rechargeable storage battery systems, and electrochemical conversion systems. We will also investigate the characteristics of existing electrode systems, ionic conductors for batteries with special emphasis on nonaqueous fluid electrodes and characterization of ion selective membranes and separators.

RENEWABLE ENERGY

Let me now turn briefly to the renewable programs proposed for FY 1983.

In the early 1970's, the United States began broad-based research and development programs to increase the use of renewable energy. In the early 1970's, there were essentially no privately-funded education or training programs; no manufacturing, installation, operation or maintenance capabilities; no public budgets; and little or no overall public knowledge of renewable energy systems. Now, colleges and universities offer renewable energy education courses; industrial laboratories and field testing centers provide training

to technicians; and energy consumers have become increasingly aware of the potential benefits of utilizing alternate energy systems to meet their energy needs.

Major changes in the energy marketplace are also providing improved opportunities for renewable energy. The price of petroleum and the scheduled price decontrol of natural gas have effectively removed subsidies from competing fuels: removal of unnecessary regulatory burdens has streamlined siting requirements; and R&D tax credits will stimulate private sector technology development. For a number of renewable energy technologies, the R&D has been essentially completed, and industrial capacity as well as consumer demand has built to the point where the private sector can assume primary responsibility for continued development or commercialization. Specifically, active heating and cooling, passive and hybrid systems, and hydropower can be, and are being, supported by private investments. While further technical investments may be possible, such developments can be left to private industry to pursue in response to market forces. Therefore no specific FY 1983 Federal funding is being requested for these technologies. Similarly, the private sector is expected, over time, to be able to take over electric energy systems and energy storage technology development. Some basic storage work will continue under the Energy Conservation Research programs described earlier.

For other technologies, the continuation of some Federal Government participation in research is needed to provide the technical base for industry to develop these concepts to a point where potential suppliers and users may begin making their own capital investment. While the strategy to meet this goal has been modified over time to reflect technical progress and the reordering of programmatic priorities, the basic premise for Federal support remains unchanged and serves as the basis for Government activity in FY 1983. With many of the

demonstration projects completed and proof-of-concept clearly established for several technologies, the Department proposes to emphasize continuing long-term research while phasing out technology development efforts that can be pursued by the private sector at rates consistent with their economic potential. The FY 1983 renewable energy budget request will be used to support these research programs at a level consistent with requirements for orderly scientific advancement.

Photovoltaic Energy Technology

There has been substantial progress in photovoltaic technology and industry development over the past several years in both single-crystal silicon and other, mostly noncrystalline, materials. For single-crystal silicon, the efficiency of commercial cells and arrays has been increased from about 7 to 14 percent, the operational and lifetime reliabilities improved by about ten-fold, and, at the same time, the cost of arrays reduced by a factor of about five. The number of photovoltaic array producers has increased from a few specialty companies, using expensive manual production processess for space applications, to more than 15, many of which use semi-automated pilot production lines to serve the growing market. Industrial sales have increased from a few kilowatts in 1975 to an estimated 5 megawatts of peak capacity in 1981, which amounts to sales of about $75 million. Over this same period, industry has invested substantially in research and development, production facilities and marketing. Industry invested an estimated $100 million for such purposes in 1981. In addition to the component, module and subsystem manufacturers, there are a large number of companies providing information, engineering, design, installation, maintenance and other services to photovoltaic system users and potential users.

For FY 1983, the Department is requesting $27.035 million to continue long-term photovoltaic research that will allow the private sector to address increased efficiency, potential cost reduction and reliability improvements.

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Experiments will be performed to better understand the cause and effects of defects in silicon crystals. Amorphous materials will be further examined to understand the fundamental electrical and mechanical properties of amorphous substances, to examine the interfaces between dissimilar amorphous materials and to develop better deposition techniques. The physical phenomena in electrochemical deposition processes appropriate to improved thin-film polycrystalline photovoltaic cells will be studied and evaluated. Research will additionally address new materials for very high efficiency multi-band-gap cells, fluorescing materials for luminescent concentrating devices, and photoelectrochemical cells. In addition, radically new concepts for ultra-high-efficiency cells will be explored with emaphsis on analysis of layer thickness, concentration gradients, and contact metallurgy.

Supporting research will also be conducted in the area of measurements and predictive techniques. Measurements of the stability of thin-film compounds and amorphous materials will be made, including identification of primary degradation mechanisms. Models to predict output characteristics of concentrator array subsystems, and accelerated life-test models and predictive techniques for silicon modules will be developed and validated.

Solar Thermal Technology

The solar thermal technology program is composed of two major activities. The research and technology development activity involves research on advanced materials and on thermochemical and thermodynamic processes. The systems and test evaluation activity evaluates the technical feasibility of first-of-a-kind solar thermal systems.

Significant advances have been realized in two major concentrating collector types: parabolic trough and central receiver systems. The parabolic trough concentrator efficiency has been improved while simutaneously reducing concen-

trator structural complexity. For central receivers, advanced heliostat designs and materials which reduced projected costs from those of the first generation designs by 80 percent have been developed. U.S. industry is the world's leader in solar thermal technology.

The FY 1983 budget request is for $18.0 million. Of this, the Department requests $8.525 million for research and technology development to support research stressing thermosciences and materials. Included will be research on optical coating of polymeric materials, methods of minimizing degradation of reflective surfaces due to environmental factors such as ultraviolet effects, analysis of high temperature ceramic receivers and optical windows, high temperature absorbers for thermal storage and the identification and evaluation of solar thermal and photon-driven processes for fuels and chemical conversion.

The request for systems test evaluation is $9.5 million to complete federally supported operation of the 10 MWe Central Receiver Pilot Plant at Barstow, California.

Biomass

A number of biomass technologies are currently competitive in the marketplace. These include direct combustion systems for the production of process steam/heat and electricity or for cogeneration, low-Btu gasification systems, and anerobic digestion systems for the production of medium-Btu gas.

Current biomass feedstock production research activities include investigations of aquatic, woody biomass and herbaceous energy resources. Laboratory investigations are being performed on the production of microalgal oils that can be used for energy applications. Research is also being done on the biochemical mechanisms controlling hydrocarbon production by macroalgal species. Herbaceous energy research and development, which includes experiments on marginal and arid lands,

is being completed in Fiscal Year 1982. In thermochemical conversion, evaluations of a variety of high-performance gasification systems for producing medium-BTU gas and synthesis gas will be concluded in FY 1982 since further development can be left to private industry. Progress is being made toward understanding the basic mechanisms and kinetics affecting the thermochemical processing of biomass through fast pyrolysis and direct liquefaction techniques.

In biochemical conversion, fundamental research is being performed on anaerobic digestion processes. Research activities also include laboratory-scale experiments on photobiological methods for hydrogen production.

The FY 1983 biomass research program will continue to address basic biomass technology research needs. The FY 1983 budget request is for $6.6 million.

Planned feedstock production research activities will focus on the development of microalgal cultivation systems. Basic research in fast pyrolysis, liquefaction, and gasification of biomass feedstocks will continue. Bioconversion program activities will support research that will enable a better understanding of the digestion of crop residues and other low-quality materials. Biochemical conversion research and development will also focus on fundamental research on the microbiology and biochemistry of digestion cultures in addition to genetic manipulation of methane-producing organisms for enhanced yields and efficiencies. Exploratory research in the biological hydrogen program will focus on areas which will contribute to increased hydrogen production efficiencies.

Wind Energy Technology

Both wind energy technology and the industry have progressed substantially in the past few years. There are now some 40 companies involved in the development of small wind systems, compared to seven in the mid-1970's, and about 20 are producing and selling commercial machines. A distribution network is also forming. Approximately 15 intermediate and large scale wind turbines from about a half

dozen manufacturers are now under construction or in the testing stage, mostly in utility power generation applications. Some of these systems have been developed without direct Federal support. Several utilities have purchased wind turbines for prototype evaluation experiments, and a few private firms are planning wind farms to produce electricity for sale to utilities.

DOE programs to develop advanced small systems are essentially complete. A major thrust of the FY 1982 Wind Program is to complete the predesign phase of the MOD-5 large wind energy system that will have peak power rating in excess of 6 megawatts. The completion of this phase will increase the capability of the private sector to pursue further development of cost competitive wind energy systems for utility applications.

The FY 1983 budget requests $5.4 million for operating funds and $0.1 million for capital equipment. The technical challenge of the FY 1983 program will be to develop methods that will enable machine designers to account more accurately for stresses and fatigue associated with aerodynamic and structural dynamic loads in wind turbines. Research will be continued on improved analytical techniques and models for predicting aerodynamics, structural dynamics and energy output performance of wind energy systems. Research will also continue on further refinements of atmospheric fluid dynamics models to predict the effects of short-term wind variability and small-scale wind velocity variations on the performance and structural loads on a single turbine and an array. Computer models for generic structural analysis will be validated using test data from existing experimental systems. Material property data for fiberglass/resin and other composites will be developed and test samples will undergo accelerated lifetime testing. Also, the 5-meter and 17-meter experimental Darrieus machines will be operated to develop and validate models that predict vertical axis wind turbine performance. Airfoils, and lift augmentation devices with high lift-to-drag ratios, will be investigated. The aerodynamic self-feathering and stall phenomena

as applied to movable rotor tips will be studied.

Solar International Program

The SOLERAS Program is a five-year, $100 million, jointly-funded solar energy research and development cooperative agreement between the United States and Saudi Arabia, signed in October 1977. The prime purpose of the Agreement is to advance the state-of-the-art of solar energy. The program covers a diverse set of solar technologies and applications, allowing participation by a large group of industrial, academic and research institutions in both countries.

Major accomplishments in FY 1982 include completion of the Solar Cooling Field Test facilities in the southwest U.S. and a photovoltaic village power system in Saudi Arabia. Additionally, work is continuing on solar cooling research, solar-powered desalination, and controlled experimental agricultural systems.

The FY 1983 budget request is for $9.5 million to complete the U.S. bilateral commitment to the Saudi Arabian government for work under SOLERAS.

ALCOHOL FUELS

The Alcohol Fuels Research program has focused on the need to develop technologies for producing ethanol and methanol from a variety of feedstocks. As part of this effort, we successfully completed steam explosion tests which reveal that steam explosion is a technically feasible pretreatment process for lignocellulosic materials. During the year we have isolated a yeast strain which produces alcohol at twice the rate of standard commercial yeast strains and another which is capable of withstanding increased ethanol concentrations. We have also isolated an organism capable of fermenting pentose sugars to ethanol, which have significant potential for increasing the yield of ethanol from ligonocellulosic materials.

We are not requesting any additional funds in FY 1983 for feasibility studies, cooperative agreements or loan guarantees since a total of $271 million is already available for alcohol fuel loan guarantees authorized by the Energy Security Act. Negotiations with 10 companies for loan guarantees are continuing. These negotiations, if successful, will facilitate the construction of plants with an annual capacity of 350 million gallons of anhydrous ethanol.

The FY 1983 budget request is for $2.9 million. During FY 1983, R&D initiated in earlier years will be brought to an orderly conclusion because this program consists primarily of activities that, over time, can be pursued by the private sector in response to market forces. Approximately $0.6 million will be used for methanol R&D, including gasification and catalysis. The remainder will be used for ethanol R&D, focusing on hydrolysis processes for lignocellulosic material. In FY 1983, R&D activities in acid hydrolysis will be completed. In the area of enzymatic hydrolysis we will conclude research to screen and select microorganisms to increase enzyme concentrations and thermal stability and to reduce their sensitivity to alcohol. We will also complete characterization of organisms capable of both hydrolyzing and fermenting either cellulose or hemicellulose to ethanol.

The final area of alcohol R&D includes activities designed to produce fuels from by-product streams. This R&D, including developing technologies to produce butanediol and methylethyl ketone from xylose, will also be phased out during FY 1983.

Geothermal

The three principal types of geothermal resources, in order of their anticipated technological readiness, are hydrothermal reservoirs (hot water and steam), hot geopressured brine containing dissolved methane, and hot dry rock.

The DOE R&D activities have significantly reduced the risk involved in finding reliable, safe and environmentally acceptable hydrothermal resources, and reduced the cost uncertainty of their use for production of both electric power and direct heat. Hydrothermal resources have been identified in 37 States; and industry is moving rapidly to exploit them. It is anticipated that the United States hydrothermal electric power capacity will exceed 3,000 megawatts by 1985, and over 200 direct-use development are currently in operation in 16 different States. In FY 1982, we are continuing to support the critical long-term research in energy conversion, geochemical engineering and materials, and geoscience technology. We are bringing to an orderly conclusion our programs for near-term development in drilling and completion, stimulation and environmental control technology, where commercial capabilities already exist. We are also completing our Geothermal Resource Development Fund activities.

The FY 1983 budget request is for $9.8 million. We plan to continue long-term, high-risk hydrothermal research including continued development of direct-contact binary conversion technology and needed research on the properties of fluids for binary systems. In geochemical engineering and materials, we will continue development of high-temperature and corrosion-resistant materials, and technologies for scale control and slurry elimination. We will continue the development and field testing of geoscience technologies to remove technical barriers and broaden the technology base for energy recovery from liquid-dominated reservoirs. We seek to expand our understanding of the physics of reservoirs which depend on natural fractures for fluid circulation as well as the optimum technologies for their utilization. A variety of geophysical and geochemical techniques will be used to characterize reservoirs and improve their performance. In addition, we will continue our support of reservoir injection technologies for reservoir management and surface aquifer protection.

In the gopressured program, we plan to complete the testing of four wells designed and drilled especially to evaluate geopressured reservoir performance under production conditions. In the hot dry rock program, we will complete the experimental work at Fenton Hill, New Mexico.

SUMMARY

As the program levels in the FY 1983 budget reflect, we have initiated a new direction regarding the appropriate Federal role in energy development and conservation, in keeping with the President's goals of economic recovery and reliance on the private sector.

Mr. Chairman, this concludes my formal statement. I would be pleased to respond to any questions.

Mr. FUQUA. Thank you, Mr. Tribble. I know you went into more specific detail about some of the programs in your prepared statement.

Mr. TRIBBLE. Yes.

Mr. FUQUA. I am sure there will be some questions from the members regarding that.

What is the total dollar value of the procurements approved by the your office in conservation and renewable energy, excluding the State and local programs, as of the first of this month?

Mr. TRIBBLE. Those that have been approved are a little bit more than a half of the total amount. It seems to me that the number is around $360 million worth that have been approved. Excuse me, just a minute. I think it is $360 million. Excuse me, just a minute, and let me doublecheck that.

It is about $360 million that has been approved.

Mr. FUQUA. Now, that does not include State and local programs.

Mr. TRIBBLE. No. Let me check. Yes. That does include $100 million of State and local programs.

Mr. FUQUA. So it would be around $260 million then excluding State and local?

Mr. TRIBBLE. Yes.

Mr. FUQUA. How much of the corresponding totals for procurements have been submitted to your office for approval by the deputy assistant secretaries?

Mr. TRIBBLE. We have a system where I see only those procurement packages that amount to more than $1 million. As of this morning, there are not more than two or three that are in my in basket.

Mr. FUQUA. Do you have any dollar amount on them?

Mr. TRIBBLE. On those that are in the in basket?

Mr. FUQUA. Yes.

Mr. TRIBBLE. I would just have to grab a guess at about $15 million.

Mr. FUQUA. There has been concern expressed that procurements have been held up in your office for as long as 4 to 6 weeks because of some personal objections that you might have to the projects. These are ones that were included in the fiscal year 1982 budget. Is that correct?

Mr. TRIBBLE. I do not recall any in that category. Of course, we did not get approval to release this until——

Mr. FUQUA. Who do you have to get approval from?

Mr. TRIBBLE. OMB.

Mr. FUQUA. Even though it was authorized in the fiscal year 1982 budget, once you then sign off on it, it then has to go to OMB?

Mr. TRIBBLE. No; I mean that we did not have the authorization of the funds to spend. This is my understanding of the system. We have to have this released by them before we can go forward.

Mr. FUQUA. But do they release to you a lump sum of money or——

Mr. TRIBBLE. Yes.

Mr. FUQUA. Is it released to DOE as an agency and then doled out to the various programs? Or is it allocated for specific programs?

Mr. TRIBBLE. It is not for specific programs insofar as I know. There have been some items that we have had substantial discussion about. If you recall, in the appropriations bill there was a reduction of some $49 million that was a part of the appropriation. It took us quite a while to determine how we were going to take that reduction. We have been through a couple of iterations on that, and we think we have that resolved in a satisfactory manner now. However, there is no question but that did cause a delay.

Mr. FUQUA. We corresponded with you a few weeks ago about this very question. Do you have any idea when you may have a response to that request?

Mr. TRIBBLE. We sent——

Mr. SAN MARTIN. That has not gone out yet.

Mr. TRIBBLE. It has not? All right. I am told that this has not left, but all the decisions have been made, and I believe I can give you the information that you may need relative to it. I am sorry. I thought this had already been sent out.

There was originally some $29 million of this reduction that was assigned to conservation and renewable energy. We went through several iterations in trying to develop how that $29 million would be prorated. Then about 2 weeks ago, we had a meeting with some of the staff and the members of the Appropriations Committee, and we reviewed those allocations. The $29 million was reduced by some $14.9 million, if I remember correctly, and now we have gone through a further iteration of spreading that reduction around.

I can give you the means by which these items were put back in. I think those are your major concerns. Let me mention them, if I may.

Mr. FUQUA. I was going to say that if you desired, you could submit that for the record, if you——

Mr. TRIBBLE. Sure. All right.

Mr. FUQUA [continuing]. If you do not have all the facts right there with you.

Mr. TRIBBLE. No; I think I have it here. The Southeast Residential Experiment Station is being proposed for $1 million to be put back into that and raise that funding to $2 million.

The $6 million that had been taken out for repowering in the solar thermal category has been added back. The $2 million that was taken out in cold water pipe research in the OTEC category is added back, along with an increase in work on the submarine cable work of some $800,000.

Half a million dollars is going back into hydrogen research; $2.35 million is going back into the Heber project; and $2.25 million is going back into the solar reserve fund.

Mr. FUQUA. When do you anticipate that those funds would be released?

Mr. TRIBBLE. There is no reason that they should not be released immediately. I have signed out a memo, and it is just a matter of it getting through the system so that it will be released, I would say, very shortly.

Mr. FUQUA. The conference report on the Omnibus Reconciliation Act of 1981 authorized $6.3 million for phase 1 and the commencement of phase 2 of the OTEC pilot plant. It also was very explicit. It said: "Find as many proposals as feasible." Yet, you select-

ed only two proposals, both of them in Hawaii. Do you think that is consistent with the language which was in the reconciliation report?

Mr. TRIBBLE. We had the $6.3 million for this purpose. There was no money in the 1983 budget proposal for this activity. We have had an estimate that a preliminary design will cost on the order of $4 million. Therefore, we are coming to you for a deferral of $4 million so that we will have money for a preliminary design.

That was one of the constraints, but the principal reason why only two were selected was the technical merit of the proposals.

Mr. FUQUA. Do you think that provides for the need for diversity of site and technology in the program? Does it answer that requirement?

Mr. TRIBBLE. It certainly doesn't address all of the variations of all of the proposals; however, if we are attempting to produce a system that will be successful in converting the small temperature difference in the ocean to electric power, we feel that these two have the best chance for success. It does provide diversity. We think this is the best way to move forward with the technology so that it will be successful and then can be utilized elsewhere.

Mr. FUQUA. You don't have any plans then to expand that to give you more diversity?

Mr. TRIBBLE. No, we do not.

Mr. FUQUA. Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman. Yes; I would be glad to yield to the gentleman.

Mr. FISH. Mr. Chairman, I ask unanimous consent that my opening remarks appear prior to the leading witness' testimony. Of course, I would like to join the rest of you in welcoming him.

Mr. FUQUA. Thank you. Without objection, your statement has already been submitted.

Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman. Mr. Tribble, I mentioned the Pacific Northwest Pacific Power Planning and Conservation Act, that it is a regional project. To what extent has DOE considered the impacts of this program in formulating its 1983 budget request? Is there any money going to that region?

Mr. TRIBBLE. Yes; generally speaking, the budget that we have submitted for conservation and renewable is completely independent of the moneys that are authorized for Bonneville.

At the same time, we do recognize that is a regional activity. On the other hand, their charge is to acquire resources from renewable sources, from cogeneration facilities, and for alternate fuel capability.

In addition, some of the work they will be doing is buying conservation or buying resources, if you will, through conservation in reducing the amount of power that is required per household and for the industry in that area.

Certainly, a great deal of the work that Bonneville will be doing will be valuable for the rest of the Nation. We would expect to be sure that the things that they develop that are cost effective are made known to everyone else.

Mr. WINN. Well, I understand that. I am sure that our Nation will benefit from that, but I have a breakdown here right in front

of me. In the home energy efficiency improvement area, for instance, residential weatherization, water-heater wraps, shower-flow restrictors, flow controls, solar heat pump, water heaters are all in the 1980 budget. Those things will only benefit the people in that region, and I am not trying to pick fights with the people in the Northwest part of the country.

I am trying to figure out if DOE has estimated the impacts of this initiative on the development of new conservation and renewable energy technologies? How do you relate between the two?

Mr. TRIBBLE. The activities that Bonneville will be implementing are known as you just mentioned. Those are known means of reducing energy consumption.

Mr. WINN. Yes.

Mr. TRIBBLE. Our budget is aimed primarily at research and development of additional means by which we can assist the industry.

Mr. WINN. I don't know how much—they are buying windmills and things of that type, too, aren't they? Are you sure of what they are doing and how it affects your program?

Mr. TRIBBLE. The only windmills that they have are the three DOE mod two machines. They are operating these wind machines. They have no firm commitments to buy additional wind power. They are sending contracts out to their wholesale customers asking them to make submissions back to them of conservation and renewable types of resources they will have available.

Mr. WINN. Let me change subjects, if I might. In his recent budget request, the President said that he may recommend the repeal of several energy tax credits when he submits his tax package to Congress in the near future.

The credits which would be subject to repeal would include the business energy tax credit.

Mr. TRIBBLE. Yes.

Mr. WINN. What else is he talking about? Is he talking about the alcohol fuels tax incentives and the various other energy tax credits which have been passed in the Energy Tax Act of 1978 and the Windfall Profit Tax Act?

Mr. TRIBBLE. Yes.

Mr. WINN. Does DOE support the repeal of any of these tax credits or all of them?

Mr. TRIBBLE. Well, I personally will support whatever is proposed. I do think it is necessary to look at the affect of the 1981 tax bill that was passed as it does relate to the energy tax credit.

The additional accelerated depreciation, as it is provided for in the 1981 bill, will have a great offsetting effect to the investment tax credit for energy property that was provided in the 1978 act so that you will have a substantial shifting which will be not only for energy property but will be for all industrial process equipment. This will give industry a great deal more flexibility to spend money in the areas where they see fit to reduce their energy expenditures.

Mr. WINN. Well, to what extent did you consider the impact of these tax incentives in formulating your 1983 budget request and recommendations?

Mr. TRIBBLE. I don't know that it was a tremendous influence. Certainly, the tax credits were on the books then. The additional 10-percent investment tax credit for energy property was in effect.

We realize that it would certainly enhance the ROI of a lot of projects that industry might come along with.

However, then there was another provision of the 1981 tax bill that does go to the research and development activities. That is that the companies can take a 25-percent investment tax credit for all the research and development which exceeds the average of their last 3 years.

If you take the case of an industry that is profitable and in the 46-percent tax bracket, this amounts to approximately a 70-percent Government participation in additional R. & D. above the level for the prior 3 years. This is quite an incentive for those companies in that category to go ahead and spend money for research and development.

Mr. WINN. Mr. Tribble, I have just returned from a meeting with the Canadian Parliamentarians. I was on the energy subcommittee of the three committees involved.

They charged us with lapsing into a crisis, and I believe you basically verified that we depend on OPEC for about 50 percent of our crude oil now. Is that about right?

Mr. TRIBBLE. I believe that is right.

Mr. WINN. What is that percentage?

Mr. TRIBBLE. I am sorry. I do not have the figure on the OPEC portion. The last number that I saw for net imports was on the order of, I believe, 4.12 million barrels per day of net imports.

Mr. WINN. What percentage is that?

Mr. TRIBBLE. And the last number that I saw was about 2.7 million barrels per day of crude. Of course, not all of that crude comes from OPEC nations.

Mr. WINN. All right. Let's go back. What percentage of imports do we rely upon to supply our petroleum needs?

Mr. TRIBBLE. I will have to give you good numbers for the record.

[The information submitted for the record follows:]

Crude oil and petroleum product imports for 1981, excluding imports into the strategic petroleum reserve, averaged 5.7 million barrels/day, or almost 36 percent of total petroleum products supplied for our domestic use. Of the amount imported, 3.3 million barrels/day or about 58 percent, were supplied by OPEC. This compares with imports of 6.9 million barrels/day in 1980, of which 4.3 million barrels/day, or about 63 percent, were supplied by OPEC.[1]

My recollection is that our requirement is on the order of 17 million barrels per day. If our imports are on the order of 4 million, then, of course, that would bring it down to a little bit below 25 percent.

However, here again, this is recollection of numbers——

Mr. WINN. All right.

Mr. TRIBBLE. I would rather give you the accurate numbers for the record.

Mr. WINN. Yes. I will accept that. Let's skip the exact figures. Their contention is that if, for some reason or another, the OPEC countries and the other countries that export fuel oil to us—or crude—would just cut if off, just stop it, they figure that we can't go on our own. We are not self-sufficient yet.

At the same time—they weren't being nasty about it, let me emphasize that point—they point out that we have let our synthetic

[1] Source: Monthly Energy Review, February 1982.

fuels program slow down. We have let our gasohol program go. Out in the Midwest, our colleague who is not here, Mr. Glickman, was trying to stimulate interest in gasohol; you can hardly find those stations any more. The signs went up for 1½ or 2 years, and now they are down because we don't wait in lines anymore for fuel, for gasoline, or diesel.

Are they making a strong point that maybe we are letting down, and about the only time we really react or get revved up particularly in research and development is when a crisis develops—the crisis being human nature and human beings being unhappy basically when they are cold or when they have to wait in gas lines?

Mr. TRIBBLE. I could understand that would be their point of view. However, they may not understand some of the influences that are at work here that will alleviate that situation.

If you look at the transportation sector, for example, the new cars are getting a very good mile-per-gallon rate as compared with the old ones. As the old autonobiles in the fleet are phased out and are replaced by the new ones, the fleet average is going to continue to increase. We saw a substantial increase in 1981. I think this is an influence that will continue.

Mr. WINN. I might say that they are aware of that.

Mr. TRIBBLE. All right. The very price that we are having to pay for energy now is going to be a continued incentive for the residential and commercial, as well as the industrial sectors, to continue to spend money for conservation measures.

In industry, generally speaking, all the easy things have already been done. Many of the things that need to be done beyond this point are going to be fairly capital intensive, so that the accelerated depreciation, again, in the 1981 bill will give the industry an opportunity to go ahead and modify processes and put in more energy-efficient equipment and take an accelerated depreciation on it. These are factors that lead me to believe that we will continue to have increased energy-utilization efficiency irrespective of the amount of oil that we are having to import from foreign sources.

Of course, there is argument on both sides of this question. I think we would have to recognize that if the economy picked up, certainly fuel demand would pick up and this situation would reverse.

However, I think that the influences that are at work will certainly have a modulating effect on the amount that it does resume.

Mr. WINN. Thank you, Mr. Tribble. Thank you, Mr. Chairman.

Mr. FUQUA. Mr. White?

Mr. WHITE. Thank you very much, Mr. Chairman.

Mr. Tribble, earlier you stated in your opening remarks that one of the reasons for the reduction in the Department of Energy's activity was an improvement in our energy picture. Could you give us a description? I realize that you have been onboard for maybe a year.

Mr. TRIBBLE. Yes.

Mr. WHITE. Therefore, I am going to cast you as a very objective impartial observer. What percentage of the improvement could you attribute to the activities of the Energy Department as opposed to general energy changes through other natural forces?

Mr. TRIBBLE. Fortunately, I don't have to depend upon my observation there. There has been a recent study made, I believe, by Oak Ridge National Laboratory, that indicates that about 95 percent of the reduction, or let's say the improvement in energy efficiency, has been in response to price changes; about 5 percent has been in response to Government activity.

Mr. WHITE. So you would say that most of that 5 percent would attributed to the DOE then, I presume?

Mr. TRIBBLE. Yes, yes; I would say that.

Mr. WHITE. Now, the administration has announced its intention to eliminate the Department of Energy. That puts you in the role of either an embalmer or a cremator, I am not sure which. Whether it is a cremation or an embalming, to what agency do you anticipate any activities would go? Would they just dissipate and go nowhere?

Mr. TRIBBLE. No, they would not dissipate. It is my understanding that all of the activities now in conservation and renewable energy would go to the Department of Commerce. Therefore, it is, here again, my understanding that this would be a simple movement out of the Department of Energy into the Department of Commerce. The research and development activities in our organization would continue in the new organization.

Mr. WHITE. Talking theoretically, do you see any advantage of creating a non-Cabinet post—a non-Cabinet agency called the Department of Science—in which pure science and other scientific endeavors of all the departments of Government could be pursued?

Mr. TRIBBLE. I have to be honest and say that I have never given that any thought. As you well know, the latitude of scientific endeavors that we are involved in are so broad that I think you could make an argument on either side. It makes some sense to have it all in one organization; however, on the other hand, if you look at the activities in the Commerce Department that are in a way related to the activities in the Department of Energy, the merger of the two makes a lot of sense.

I don't remember all of the details, but I have seen a comparison chart of these activities.

Mr. WHITE. What happens to all the regulations that have promulgated under the Department of Energy from its inception to the present if the Department is transferred into a different agency?

Mr. TRIBBLE. I am sorry. I didn't hear you.

Mr. WHITE. What happens to the regulations that have been set down by the Department of Energy during this period of time?

Mr. TRIBBLE. It is my understanding that they would continue to be in effect under the new organization.

Mr. WHITE. I am going to yield, if the committee would not object, for the purpose, of allowing about three questions to counsel because she has some comments on some of the testimony you have given.

Counsel, you go ahead at this time.

Ms. KREBS. Thank you, Mr. Chairman. I have a number of questions concerning your statement about tax credits. In terms of the investment tax credit for R. & D., you state that that equates to

essentially a 70-percent investment or a 70-percent participation on the part of the Government in some of these activities.

Mr. TRIBBLE. Yes.

Ms. KREBS. We have received a lot of information from the private sector about that particular investment tax credit in the time that has elapsed since its passage. Our information indicates that since it is an incremental tax credit based only on the increments above current investment, and since it is based only on the expenses for people that are engaged in research and development as opposed to capital equipment, it is not going to make terribly much difference to corporate profitability or plans to invest in additional R. & D. particularly in the energy area.

Who has spoken to you that leads you to believe that there will be an additional investment in energy R. & D., in particular, within the next year or two?

Mr. TRIBBLE. I don't know that I have spoken to anyone whose name I could call. I was looking at the time as a person who has been in the industrial sector for 35 years, and I was thinking that if this kind of a tax credit is available, certainly a company in the posture to increase or to use it could increase their research and development and take advantage of it.

I was not aware that it had been interpreted to mean only people. However, as you know, research is terribly people oriented.

Ms. KREBS. Thank you, Mr. Chairman.

Mr. WHITE. Mr. Gregg?

Mr. GREGG. Thank you. Mr. Tribble. I have some problems with the basic concepts here that we are seeing relative to the conservation and renewable energy budget. The problem is, as I see it, the DOE being inconsistent in interpreting its policies.

We have a situation where you are essentially zeroing out these items. If you take the entire total of solar, geothermal, hydropower, and energy electric systems and you drop from $1,048 million in 1981 down to $100 million in 1983, for all intents and purposes you are closing up shop on most of these items.

Yet, we have an aggressive expansion on the nuclear side, especially in the area of the Clinch River breeder reactor, a single project which totals $253 million just for this year which is twice what the entire budget is for conservation, solar, and renewables.

Now, how can you justify to us, and how can you folks come up here and tell us that you are taking a marketplace strategy when you are basically putting in place a nonmarketplace item like the Clinch River breeder reactor?

Mr. TRIBBLE. I am going to have to plead that is not my bailiwick. I don't have any influence over what is done in that part of the Department of Energy.

I would offer this observation that this is the difference in cost when you build hardware. Now, we have spent—you mentioned a minute ago that the amount in 1981 was in excess of $1 billion. That was in that period of time when we were authorizing and letting contracts and building many demonstration projects such as parabolic troughs, parabolic dishes, the solar-power tower, flat-plate collectors, and this kind of activity. It is very expensive.

Now, we have reached the point where most of that is in place. We are getting the data from it that we built it for, but we are not going forward with building additional hardware.

It is my understanding that in the breeder reactor program that they are simply now coming into the phase where they will have to build the hardware. From my limited knowledge, that is where a large portion of the cost is.

Mr. GREGG. But if we accept your logic that the marketplace should settle whether or not the hardware is being built, how can we justify spending $253 million this year and $3 billion over the next 5 or 6 years on one piece of hardware where we have just wiped out the entire conservation, solar, and renewables budget?

Mr. TRIBBLE. Most of the technologies in the conservation and renewable activities have been moved forward to the point where they are readily available. You can go and buy a wind machine. You can go and buy a photovoltaic array, a parabolic trough, a central receiver. Most of those things we have moved forward to the point where if they are economical they can be built.

On the other hand—and here again, I really shouldn't be talking about the breeder reactor because I don't know enough about it to intelligently discuss it—I know of no such device in this country at this time, and I would presume that the building of it is to gain information from its operation. That is certainly a very layman point of view to that project.

Mr. GREGG. Well, let's follow the point that you made along a little further then. Didn't you say earlier in your testimony—maybe I misunderstood it—that we are getting into the capital-intensive part of the alternate source energy activity now?

Mr. TRIBBLE. No. I said that industry is getting into the capital-intensive part of investments that will further improve energy efficiency utilization. For example, in the early years right after the embargo, all of us went around and put insulation everywhere and closed up and took the housekeeping measures that were relatively inexpensive, and that did make a good bit of difference. Now, we are faced, having done that, with industry having to move into process changes and replacement of equipment with more energy-efficient equipment. That is the statement, I believe, certainly I intended to make. Industry has moved now into the area where further improvement in energy efficiency is going to be by virtue of the installation of capital-intensive equipment.

Mr. GREGG. Could I ask Dr. Savitz a question? Is that your position also? Your budget is in conservation where we have really made some big savings at least in my State of New Hampshire. We have cut the use of oil down from 1,600 gallons per family down to about 800 gallons per family, a cut in half in the last 4 years, much of which was due to conservation, and a significant amount of which was due to transferring to wood.

Your budget has dropped down to $18 million from $144 million in 1982 and $279 million in 1981. Is it your position that if you had funding, there is no further project of a high-risk, long-term nature in the area of conservation that we should be looking at that is probably not going to be undertaken by the private sector because of the high-risk, long-term deterrent factor?

Ms. SAVITZ. Well, the present budget already has some high-risk, long-term technologies in basic research that has some long-term payoffs in the multisector. In formulating the budget, we picked out those that had the highest priority with meeting the criteria of long-term benefits.

Mr. GREGG. Can you list a few of those for us?

Ms. SAVITZ. We will be continuing some work on the relationship of windows and walls, looking at indoor air quality; some industrial heat pump activity; continuing work on the battery related to electrical vehicles, aluminum air, sodium sulfur, some high-risk battery research; in addition to considering some basic combustion work.

Mr. GREGG. What are some of the long-term, high-risk conservation activities that you have dropped and you will not be looking at?

Ms. SAVITZ. We will have come to, in this year, completed phases of some work related to high-temperature heat-recovery methods, ceramic recouperators, advanced cogeneration systems, some high-temperature heat pump work.

We are working in some of those with the Gas Research Institute to try to pick up the next phase.

Mr. GREGG. Well, I guess, I will get back to my question. Conservation just seems to be an area where we can really save some significant amounts of oil. For those of us from New England, we would like it if we didn't have to use any oil at all. That is just a personal bias that we have which has been built up over the last few years.

Yet, you are telling us that there are no areas of conservation where you as a Department feel that you should be participating because you feel the private sector is going to pick up the entire conservation side.

Now, if that is true, that is fine. I think that is very effective, but is it true?

Mr. TRIBBLE. One of the factors that I think needs to come into play here is order of priority. In the tight budget constraints that we have, I would have to say that certainly there are other things that can be done. Just what their value would be in improving the conservation activities in the United States would have to be compared against the cost of having to borrow the money to do this at present-day cost.

Mr. GREGG. Well, you see, now, Mr. Tribble, you are sort of throwing me a slow-fast ball or something. You know, I asked you earlier if you are going to use that as a baseline; if you are going to say that you are going to compare it to the cost of borrowing that money from the marketplace, then how can you possibly justify an energy program which has in it the Clinch River breeder reactor? You have got to the consistent in the Department. Right? You are not being consistent. You are being inconsistent.

Mr. TRIBBLE. I guess that the person in charge of that organization would have to answer that question.

Let me make one other comment along this line. You know, when you talk about conservation and renewables, it is kind of like talking about apple pie and motherhood. It is all good.

When you start looking at the details of the projects that can be done that will produce a beneficial effect, in getting down into the details of those projects, you find that many of them are going to be done by other people. However, primarily the price will drive. There is not a lot of research that needs to be done in conservation.

Mr. GREGG. Well, all right. If that is true, then why did the Energy Research Advisory Board rate it as a priority and rate Clinch River as something that shouldn't be proceeding? Your own advisory board is telling you that if you are going to use your marketplace philosophy, you shouldn't even pick Clinch River, but rather, you should pick conservation.

Why is your advisory board disagreeing with you?

Mr. TRIBBLE. I am sure that I do not know. On the other hand, the advisory board made a number of recommendations that I don't believe this committee would agree with. We have to look at that advisory board as merely one of the sources of advice that we get.

They did come down on the side generically for more conservation, but they did not give us any specifics. Now, since that time, we have asked them—and they have formed a new conservation committee—to come forward with specific recommendations of projects wherein they think research would be helpful.

We expect to get that later this year.

Mr. GREGG. Now, if you get that list of projects, and that list does not have $253 million for Clinch River on it but does have, say $10 million in conservation to expand the heat pump concept or the cogeneration concept because they don't feel that the private sector is going to pick those up, is it going to be your department's recommendation to proceed in that way or are you going to continue to proceed with the present proposal?

Mr. TRIBBLE. It would be my responsibility to look at those recommendations that have to do with conservation and renewable energy and recommend those that I felt were worthwhile. The matter of whether or not the breeder reactor would be also included would be the responsibility of others in the Department.

Mr. GREGG. Well, let me ask you another question. I think this committee has some suspicions about the breeder reactor, at least, some members have some suspicions about its utility in the marketplace, as a competitive energy source, whether or not it is viable. Yet, it is the biggest single item in the budget, I believe. It is twice as large as your entire budget in conservation and renewable.

If the breeder does not happen to proceed as a result of action of this committee, and if some of the funds are restructured so that we come in below the President's budget—and I assume we will because we always have—when we have restructured the budget, I would be interested in knowing where you think those dollars should go? Should some of them go into conservation and solar?

Mr. TRIBBLE. You know, I would get into a whole mess of trouble if I answered that question.

Mr. GREGG. Well, let's leave out the premises of the question of how we are going to get you the money. Let's assume that the money is going to come and it is going to be under the President's budget because some of us believe that conservation, solar, wind,

and geothermal have a lot more potential than maybe some other items in the present budget as structured; where would those dollars be best spent within your budget?

Mr. TRIBBLE. If you do, as a committee, put additional funds in the budget, we would like very much to have an opportunity to discuss with you in a hearing or at whatever convenient time and place the technical merit of the proposals so that we can all be assured that the money that we would be spending would go for valuable research.

I am really just not prepared at this time to tell you where we would do so.

Mr. GREGG. But we need that list of priorities because there is going to be an attempt by this committee, I can assure you, to restructure this budget so it stays below the President's line, but also takes funds out of an unknown factor and moves them into other areas, specifically, into conservation, and solar, and geothermal, and hydro. We need the list of priorities. Can you get us a list of priorities?

Mr. TRIBBLE. We do not now have a list of priorities.

Mr. GREGG. Well, as I look at that panel, I am sure that list could be developed, could it not, within the next few weeks?

Mr. WOLPE. Would the gentleman yield?

Mr. TRIBBLE. We will certainly work with you in any way that we can to develop that kind of information.

Mr. GREGG. Well, for example, how would you fund a $20 million program in industrial energy conservation? Can you give us a list of priorities in that area?

Mr. WOLPE. Could the gentleman yield with respect to the question?

Mr. GREGG. Yes; I yield to the gentleman.

Mr. WOLPE. If they don't have a list of priorities, could they at least indicate to us what criteria they might apply in developing such a list of priorities?

Mr. TRIBBLE. Sure.

Mr. GREGG. You can give us the criteria then?

Mr. TRIBBLE. Yes; let me talk about the one that you just mentioned on industrial programs. For example, all of us have to recognize that there is a lot of work that is being done in industry, a tremendous amount of research that is going into new processes and means of reducing energy consumption.

If we were to undertake to go forward and do this research for industry, no matter what we did, we would be doing a little favor for one group of people here and another group of people there.

What we are trying to do is to do work that is generic in nature. Let me give you one of the criterion for one of the examples. We know that most of the combustion processes, for example, are relatively inefficient. Internal combustion engines produce carbon monoxide. The burning of coal and oil is not as efficient as it should be.

We are going forward with research and development work to improve the efficiency of combustion, not only of middle distillates, gasoline, but also of coal, powdered coal, and other things. Therefore, if we can upgrade the process of using fuels, then this is a technology that can be adapted across industrial segment lines.

Those would be the kinds of things that we would like to come up with for additional funding if we have those funds made available.

Mr. GREGG. I think that is a very laudable approach. I guess, what we would like is to get those criteria spelled out more specifically and then get a prioritizing of the different areas: solar, geothermal, wind, conservation, and hydropower, and the criteria within those specific areas. Then if you have specifics within those criteria, we would like to get those, too.

Mr. TRIBBLE. While we have not established formal criteria for such a purpose, we would be happy to work with the committee on any proposed allocations of additional resources.

Mr. GREGG. I know that there are at least 150 or so projects pending in the industrial conservation program.

Mr. TRIBBLE. Oh, I am sure that it would be easy to increase that list.

Mr. GREGG. Right. What we are interested in knowing is, assuming we are going to stay within the President's budget—which I am sure we will—and assuming we are going to put more money into this area and take it from somewhere, where can it be most effective? Some of us feel that this is the area where we can save money and produce more energy for this country.

Mr. TRIBBLE. We would be pleased to work with you on that.

Mr. GREGG. Thank you very much.

Mr. FUQUA. Mr. Tribble, we are going to have to take a break and go and approve the journal for yesterday. We will resume in just a few moments.

The subcommittee will stand in recess.

Mr. TRIBBLE. Thank you, Mr. Chairman.

[Short recess taken.]

Mr. FUQUA. The subcommittee will resume.

Mr. Lowery?

Mr. LOWERY. Thank you, Mr. Chairman. Mr. Tribble, the Energy Research and Development Act of 1974 has its genesis in this committee. It required 6 to 10 geothermal demonstration powerplants to be online by the end of 1980. That is now law.

The previous administration failed to comply with this law. Given the background, can you explain why this DOE administration is not making a good-faith effort to comply by full funding its previous commitment to construct the world's first commercial scale geothermal binary demonstration plant at Heber, Calif.?

Mr. TRIBBLE. Let me talk about that just a little bit. We have recently been in meetings with the other people who are working in the Heber program. As you know, EPRI is interested. I believe the California Energy Commission and certainly the California Gas & Electric are interested.

We have had a meeting with them relatively recently. We have looked at a number of technological problems there, and we are now in the process of trying to work a renegotiation of the contract.

Mr. LOWERY. By "technical problems," what are you referring to?

Mr. TRIBBLE. One is the down hole pump. When you consider that these geothermal resources are at a relatively high temperature, in addition, they have high impurities which would scale up a turbine or pump if they were allowed to come out of solution.

Therefore, the water must be kept under pressure so these impurities will not plate out. In order to do this, we have to go down into the aquifer, down into the geothermal region, with a pump which can pick up the water at that level and pressurize it so that it will continue to be under pressure all the way up through the heat exchanger and back down through the reinjection well.

Of course, this is a highly corrosive material. The material thus far has been that we have not been able to operate a down hole pump for more than 2 months without failure. This is one of the technological problems that does need to be resolved, and we are working on it.

Therefore, it should not be a complete deterrent to this project; however, we are in a posture of now trying to renegotiate with the idea that we can go ahead with the project.

Mr. LOWERY. Can you be more specific in this renegotiation?

Mr. TRIBBLE. I would be reluctant to under the circumstances because it is a matter that is being negotiated. I am afraid that I would be saying things that I shouldn't say that would adversely affect the negotiations.

Mr. LOWERY. Well, Secretary Edwards has previously indicated that DOE would complete design and make some long-lead procurement and then turn it over to the private parties. Is this still the plan of the Department of Energy?

Mr. TRIBBLE. Yes.

Mr. LOWERY. Mr. Tribble, I am not qualified to debate a complex engineering issue. I have been to the Heber plant on several occasions. I know that a good deal of progress has been made. I know that utility rates in southern California are among the highest in the Nation. We have a huge reservoir not only in southern California but as the U.S. Geological Survey points out, in some 37 other States where resources could be tapped once the binary process is proven out, and therefore, would probably serve some 25 percent of the Nation's needs.

It just strikes me that is too valuable a resource for us not to pursue aggressively.

As I say, I know that we are in a pioneering area. I also know that top technical people at the Electrical Power Research Institute and at Fluor Corp. do not foresee any insurmountable technical problems at Heber. In fact, I have been advised that the project can operate successfully for 30 years on a two-phased flow of direct nonpump flow of brine. This would still prove the commercial scale application of a binary conversion process which is really the goal of this project. It would also comply with the law and serve the needs of the project. Therefore, I have problems in understanding the Department of Energy's reluctance when we have those kinds of benefits along with no insurmountable problems ahead of us.

Mr. TRIBBLE. We would not say that these are insurmountable problems. We would just say that at the present time we haven't solved them. Part of this work would be directed toward solving the very problem that I mentioned.

The people from Fluor have indicated that they feel that they can make substantial progress in this development.

Mr. LOWERY. Well, how are you going about solving it when it seems that there has been a reluctance—I wouldn't necessarily use

a word so bold as an "impoundment," but certainly it is a reluctance in terms of the flow of funds that the Congress has authorized and appropriated.

Mr. TRIBBLE. I am not aware of any holding back of any expenditures. We had come right up to the more or less fork in the road when we had to make commitments for equipment which would have involved the DOE a great deal more. In other words, we were at a fork in the road where we would have had to make a decision to either go forward and order this equipment which would have been quite expensive. It seemed to us that that was the appropriate time to sit down and rethink and retalk about the contract.

Mr. LOWERY. Are you referring to the boilers?

Mr. TRIBBLE. The turbine, primarily.

Mr. LOWERY. Yes.

Mr. TRIBBLE. So that is what we did. This has taken place in the last month, so it is an active project at this time.

Mr. LOWERY. Mr. Secretary, if the binary process is proven, wouldn't it increase the value of geothermal resources on Federal lands?

Mr. TRIBBLE. Yes; the binary aspect of this project is not as problematical as some of the others. The binary cycle is really fairly well understood. It is in use in many places. The binary cycle permits us to use a resource that is relatively low in temperature and pump it up to a usable level.

Mr. LOWERY. And it has already been proven at 2 megawatts, and this project would get it up to a 50-megawatt or commercial-scale size.

Mr. TRIBBLE. Yes.

Mr. LOWERY. Well, if I am properly interpreting your comments, despite some of the things you said in your statement on page 8: "While further technical investments may be possible, such developments can be left to private industry to pursue in response to market forces," the Department of Energy is yet committed to proving this process and will yet continue to fund it, either through a satisfactory negotiation with the principals or continuing without ongoing authorization and appropriations progress in Congress?

Mr. TRIBBLE. If I understood that question correctly, yes, we are committed to go ahead and work with the other partners in this project to a satisfactory conclusion.

Mr. LOWERY. Are you keeping in mind two points as this negotiation process continues? Also quoting from your statement on page 8, you mentioned: "R. & D. tax credits will stimulate the private sector technology development." I am fully supportive of that. However, the Ways and Means Committee specifically exempted public utilities by law from participating in those tax credits.

Is that consideration being factored into your negotiations; that is, those advantages would not be available to the principal that may be available to some other parties?

Mr. TRIBBLE. Certainly. That is a consideration that we recognize.

Mr. LOWERY. And also, the GAO report that was prepared at the request of this committee stated that private- sector financing is very, very difficult to find. The San Diego Gas & Electric Co. has

twice made monumental efforts for private financing and has not been successful.

Mr. TRIBBLE. Yes.

Mr. LOWERY. Well, I wish you would keep those points in mind, Mr. Tribble, because it strikes me that this is an extremely important technology to this Nation, as many of the renewable sources of energy are. However, this is probably the most promising, the most widespread, and we need to get past the binary process in order to take advantage of it.

Quite frankly, I am not sure we are quite there in terms of a full private-sector response at this time. We need to prove the commercial viability. The law so states that we should be moving in that area and in that direction.

I will look forward to some updates from the Department of Energy in terms of what progress is being made.

Thank you, Mr. Tribble. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Lowery.

Ms. Schneider?

Ms. SCHNEIDER. Mr. Tribble, I wonder if you might summarize for us the basic premise that your department has used in developing the budget for conservation and renewables.

Mr. TRIBBLE. Yes. The basic premise is that we want to move away from the demonstration of known technologies and installation of hardware, and move to a mode where we are doing research that is more basic that will be useful across the spectrum.

One example that I gave earlier was the work that is going forward in analysis of combustion processes. If I may say this, it is somewhat repetitive, but many of the combustion processes are relatively inefficient. For exanple, an internal combustion engine is very inefficient.

We have work going on which will enable us to actually look through a quartz cylinder head of an engine in operation and make an analysis of the products of combustion which the process is going on.

If we can do these things, then we can get a better understanding of the processes. We think that this will be valuable across the spectrum. That is the kind of thing which we feel is our responsibility to do.

Ms. SCHNEIDER. Well, one of the responsibilities of this committee is to analyze the various programs and to give our input as to where we believe research may be more useful—and to use your own words—and more basic.

Certainly, I think there is a clear demonstration that this committee has felt that conservation is a priority. Part of what we use is a cost-benefit analysis because we are in a position of representing people who are concerned about the price of the energy that they are receiving.

Mr. TRIBBLE. Yes.

Ms. SCHNEIDER. I think that most of the testimony that has come before this committee—at least so long as I have been here for the past year plus—has clearly indicated that the most efficient expenditure of our dollars is in the area of energy-efficiency improvements.

Regrettably, that is essentially contrary to all of your recommendations. When I asked for your philosophy in making your decisions, there was no clear-cut cost benefit analysis.

We have also had testimony before this committee that clearly indicates that the private sector is not going to pick up this and numerous other things. I think it is important for us to ask the private sector questions along these lines. In testimony before this committee, they have very clearly stated that it is impossible for them to continue to fund what you refer to as being "near-demonstration-phase projects."

Mr. TRIBBLE. Let me see if I can address your question of philosophy on conservation a little more clearly. It is our philosophy that the very price of energy will now cause those cost-effective measures that do improve energy efficiency to be taken.

I was in industry for many years, involved in an industry that was energy-intensive. When the price of fuel escalated as it did in 1973 and since that time, that industry as well as others set about immediately to determine what they could do to drop the percent of manufacturing cost that was going into their projects.

Ms. SCHNEIDER. All right. Mr. Tribble, if I might just interject——

Mr. TRIBBLE. Yes.

Ms. SCHNEIDER [continuing]. Because when I went through this the other day before another committee——

Mr. TRIBBLE. Yes.

Ms. SCHNEIDER. It is a pleasure to be here with you again, but I think it is important to have it on the record of the Science and Technology Committee. Various studies including those that DOE has requested to be completed clearly indicate that over two-thirds of the conservation which has taken place has been the result of a loss productivity due to factories closing down in New England and people being laid off thereby cutting down the use of fuel, or driving to work, or whatever, and essentially from doing without.

Now, I think that if less than one-third of the conservation has come from investments in energy efficiency, should be our goal as decisionmakers for energy policy that the kind of conservation that we want to promote is not doing without, but rather doing better with what we have got?

Mr. TRIBBLE. Yes, certainly. I would agree with that.

Ms. SCHNEIDER. Now, do you not agree that there is some room for leadership on the part of the Federal Government in that area?

Mr. TRIBBLE. Here again, we feel that if we let the market set the price that people and industry anywhere will have to pay for energy that is ample incentive for us to find ways to reduce the amount of energy that we need per unit of production, per household, or per mile traveled

Ms. SCHNEIDER. Now, let me just point out that you have worked for a big corporation, and what I want to know is what are the small businesses going to do? What is the housing industry going to do? They do not have the capital for energy-conservation research, now do they?

Mr. TRIBBLE. The building industry certainly is a fragmented industry and there are not many big players that would be interested enough to spend large sums on research and development.

On the other hand, there is not much unknown about how to make a building more energy efficient. At least, there is a great deal more known about how to do this than we have been implementing.

Ms. SCHNEIDER. Well, I think that it is interesting to note that when we compare ourselves to other countries, France, Germany, and Japan all find it necessary to increase their budgets for research in the conservation area.

I think probably one of the most advanced technologies is the heat exchanger that has really been perfected by the Japanese. I don't see any leadership on the part of the United States to go ahead with that. Certainly, industry hasn't moved ahead.

What about the whole idea of information generation from the Department of Energy? How are the folks back home supposed to know what technology is available, what technology is now there for the taking?

Mr. TRIBBLE. Well, we, of course, have had an information dissemination organization which was very active. We now have a contract with the Franklin Institute that has, as I understand, reached more than 50,000 inquiries a week in the past. Therefore, we have been disseminating this information as the mail and the calls have come in.

Ms. SCHNEIDER. Well, those kinds of numbers pretty well indicate that it has been a successful use of Federal dollars then, doesn't it?

Mr. TRIBBLE. Yes. Now, this activity has diminished. The last figures we saw were on the order of 2,000 inquiries a week. We are making some changes in this. At one time, there was a substantial information dissemination activity at SERI, and this is being modified so that in the future the information that comes from SERI will primarily deal with the projects that are being done at SERI.

Further, all of the information that we are gathering from these demonstration activities of hardware, we expect to put into a form so that we can make it available either through NTIS, or GPO, or whatever.

Ms. SCHNEIDER. Well, the only thing I have in the back of my mind is that the budgets for all information generation at DOE have been cut substantially.

Mr. TRIBBLE. Yes.

Ms. SCHNEIDER. I question that. You know, even though you are consolidating and putting together information programs I question the capability of getting that information out with such a meager budget.

Mr. Chairman, I would like to have the opportunity to submit for the record a study that was done for DOE by DOE staff by Mr. Marlay. This study clearly finds that the Department of Energy programs have had a great influence on investments in energy efficiency. I would like permission to include that in the record, if I might. Thank you.

[The study mentioned above follows:]

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Effects on Investment in Energy Conservation of DOE's Programs and of Market Forces

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This paper addresses three points relevant to the current policy debate on energy end-use, conservation and the Federal role. These points are: (1) the effects to date of DOE's programs on investment in conservation, (2) the effects to date of natural market forces, mainly higher energy prices, and (3) the likely effect in the future of eliminating Federal programs, relying instead on market mechanisms. Estimating such effects is a complex business analytically, with many varying disciplinary approaches. This paper performs no new analysis, but attempts to summarize what information is available today. Some highlights are:

Effects of Federal Programs (Including Tax Credits)

- The effects to date of DOE's conservation programs ($781 million in FY 80) and tax credits ($620 million in FY 80) on national energy consumption are small, probably accounting for less than 5 percent of the observed reduction in energy use per unit of GNP. The effects on investment in energy conservation, however, may be larger (this is reasoned below), but still less than 15 percent of the total.

- This finding should not be unexpected. Many of the programs were not focused on the present or near-term, but on the longer-range future. Others were not even focused on conservation, but on such areas as emergency planning, energy impact aid and low-income assistance. In general, DOE's programs have focused on areas of alleged market failure where near-term payback, almost by definition, is expected to be marginal. Longer-term payback, however, particularly from R&D programs may be higher.

- Having had little effect on the whole does not mean that Federal programs are ineffective. Detailed cost-benefit analyses have shown that many of these programs are, indeed, cost-effective, some more so than tax credits. If some programs are not, others could take their place. The important issue is whether they are needed.

Effects of the Market (Price)

- The market has responded strongly to energy price signals. Significant energy savings have been achieved both by

price-induced changes in consumption patterns (behavioral changes of a curtailment nature) and by investment in energy efficiency improvements. Curtailment actions appear to have dominated the market response to date. Energy efficiency improvements by way of capital investments have had secondary effects only.

- For this reason, the effects of Federal programs (including tax credits) on investment may be larger than their effects on energy consumption. Investment is believed to have accounted for a relatively small part (one-third or less) of the overall market response. To the extent that Federal expenditures have focused primarily on promoting investment rather than on curtailment, their leverage on this type of response may have been greater than on the whole. This area needs study.

- Curtailment of energy consumption, declining labor productivity, lower standards of living and slowed economic growth appear to be the predominant market response to higher energy prices, at least in the near-term (last seven years).

- Technology based energy efficiency improvements have made their largest contributions in two areas, increased fuel economy in automobiles and new plants in industry, but their effects are still of a secondary nature, even in their respective sectors, compared to price-induced curtailment actions.

- Investment in new technologies and turnover or modernization of existing capital stock are inherently much slower phenomena than behavioral decisions to do without. It should not be unexpected, then, that investment has had the lessor effect on the whole to date.

Expectations About the Future

- An energy conservation policy based solely on price will undoubtably reach a large and significant audience of potential investors in energy efficient technology. Whether they are sufficiently motivated by price to invest is a market decision, largely dependent on the cost of capital financing.

- The single most effective policy action the Federal government can undertake to promote energy conservation is to help bring down the high interest rates on capital. To this end, recent economic policy initiatives (reduced Federal spending and balanced budgets) may do more for energy conservation than all the programs and tax credits combined.

- If high interest rates prevail, however, past behavior (the last seven years) will likely continue for some time into the future, that is, higher prices will induce further curtailment and more investment, but curtailment will continue to dominate the response.

- For this reason, additional Federal initiatives aimed specifically at accelerating investment may be desirable. If they are, non-price market incentives (tax credits, accelerated depreciation allowances, etc.) may be warranted. Federal programs (other than tax incentives) may be warranted on similar grounds.

- The existence, a lack thereof, of Federal programs aimed at accelerating investment can have a measurable effect. Their need, however, must be determined on the basis of demonstrated market failures.

- Market failure in the past may have been caused, in part, by Federal price controls and, in part, by a general unfamiliarity with conservation technologies and their potential. These barriers are now being removed. To the extent that some Federal programs were motivated on this basis in the past, a reassessment of their need must now take place.

- Lastly, many questions about the market, its responses, its strengths and weaknesses, and the role for Federal programs and incentives need to be examined more carefully. These are central issues in the current debate and should have priority on any analytical agenda for the coming year.

General Discussion

There is no doubt that the dramatic increases in energy prices since 1973 have had a profound effect on the U.S. economy. Today consumers pay, directly or indirectly, $400 billion a year for energy, 15 percent of GNP, and there is every sign that these costs will continue to rise faster than income in general.

One consequence of higher energy prices, to be sure, is reduced energy use per dollar of GNP. This ratio has declined by 13 percent since prices began to rise sharply in 1973. In earlier years, by comparison, energy and GNP appeared inseparable. As energy prices increase relative to other goods and services, there is a natural and expected market response to use less energy and, if possible, to substitute other goods and services instead.

The economic substitution of capital for energy through innovation, new or improved technologies and retrofit is one type of market response, often referred to as conservation or improved energy efficiency. In general, it means delivering the same energy service or comfort level with less energy and improved efficiency. There is also a second type of market response. This is the substitution of labor for energy or simply doing without. This is often called curtailment, self-denial, changing lifestyles or lowered standards of living. It is also called, confusingly, conservation.

Both types of market responses are operating (data is provided later). In the transportation sector, consumers are buying more efficient cars (improved energy efficiency) and driving less (curtailment). In the residential sector, homeowners are insulating their homes and lowering thermostats. In business, some industries are expanding with modern and energy efficient facilities, others are forced to shutdown. Obviously, millions of individual decisions must be made, many of them difficult ones, and the marketplace is particularly effective in bringing these about.

There is some evidence, however, that higher energy prices acting alone tend to evoke more of the curtailment type of market response than that which improves energy efficiency, especially in the shorter term. Technically speaking, the large increases in energy prices, combined with the pervasiveness of energy use in the economy in general, are believed to have caused a significant change in the preferred structure of the economy. The process of adjusting toward this new optimum has created a high demand for capital, driving upwards its price as well. As the prices of both energy and capital increase, there is a resulting shift in the economy away from both. The real price of labor, meanwhile, has remained constant or even declined slightly. The market response, predictably, is to use more of this input, driving down labor productivity. As labor productivity declines, by most measures, so does the standard of living.

The Effect of DOE's Programs

Although energy consumption per dollar of GNP has risen and fallen at various times in the post-war period, the recent downward trend is a marked departure from historical behavior. The 1980 estimate of 51,400 Btu's per constant (1972) dollar of GNP is substantially below that of any other time in the last 30 years. This reduction roughly translates into about 12 quads of forgone energy use, based on 1973 efficiency levels, or about $60 billion in 1980 energy purchases.

It is unlikely that Federal conservation programs, including tax credits, have had a significant effect at this scale. Most of these programs were intended to serve less immediate purposes. A breakdown of FY 80 expenditures shows where the emphasis has been.

	FY 80 Millions
Grants to Schools and Hospitals and Low-Income Persons	$ 342.7
State Planning Grants	98.8
Transportation (R&D and Info)	113.4
Buildings (R&D and Info)	103.4
Industrial and Multisector (R&D and Info)	79.3
Energy Impact Assistance	43.0
Total DOE FY 80 Expenditures	780.7
Corporate Tax Credits	190.0
Individual Tax Credits	430.0
Total Tax Expenditures	620.0

Approximately 40 percent of the DOE conservation budget in FY 80 was future oriented, focusing on research, development, demonstration and commercialization of high risk technologies. Such programs could have had little effect on either 1980 energy consumption or investment. Another 20 percent was of a planning nature, assisting state and local governments in preparing for energy emergencies, for the development of state energy management plans or for energy impact aid. These programs may have had some effect. The remaining 40 percent was in the form of grants to schools and hospitals and low-income persons for weatherization, intended primarily to offset the negative impacts of higher energy prices on specific segments of society rather than to motivate investment by the private sector. These programs have likewise had little effect on investment at the national scale.

Between 1975 and 1980, perhaps as much as $100 million (accumulated) has been spent on information or so-called outreach programs. These programs were intended to motivate investment and many have been effective. An evaluation of the Energy Analysis and Diagnostic Centers Program, for example, found that $5 of private investment actually resulted from each $1 of Federal outlay, with an additional two dollars planned for future years. Assuming an upper limit of $10 for $1, a total Federal expenditure of $100 million on outreach programs over several years could not have induced more than $1 billion in incremental private investment. Assume, furthermore, that

all the other Federal programs induced an additional $1 billion in investment. Together, Federally induced investments above and beyond normal levels may have amounted to about $2 billion from 1975 to 1980. The energy savings resulting from these investments would be about $1 billion per year, or about 2 percent of the total 1980 response.

Residential and business tax credits for energy conservation have also induced investments. Treasury analysts assune only $1 of incremental investment for each $1 of tax credit. Others argue that the very existence of a tax credit stimulates interest in investments much more from a marketing point of view, than from a financial point of view. Conservation tax credit claims are projected for the 1980 tax year to be about $500 million for individuals and $200 million for corporations, implying a total conservation investment in that year of about $4.5 billion. Not all of this investment, however, was induced by the existence of tax credits. Much of it would likely have taken place anyway, without the tax credit. Assuming a $2-for-$1 effctiveness, tax credits may have induced $1.4 billion of incremental investment of the total of $4.5 billion in 1980.

Extending this analysis to tax years 1977, 1978 and 1979 (period affected), perhaps as much as $4 to $6 billion of accumulated incremental investment has been induced by the tax credits, so far. These investments would return, on the average, about $2 billion in energy savings per year. Adding this $2 billion (due to tax credits) to the $1 billion (due to information and other DOE programs), the combined effect to date would be about $3 billion per year, or about 5 percent of the total 1980 response ($60 billion).

Having had little effect upon the whole, however, is not to say that Federal programs have been "ineffective." The study of the Energy Analysis and Diagnostic Centers program, for example, shows that this type of focused program is two to five times more effective in motivating private investment (per dollar of Federal outlay) than the tax credits.

The real issue, then, is not so much one of effectiveness; less effective programs could always be replaced with more effective ones. Rather, it is whether Federal programs are needed at all, particularly in view of a large and apparently successful market response. This then shifts the focus of the debate, somewhat, away from the specifics of programs and measures of effectiveness, and more toward the market itself, its strengths and weaknesses.

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The Effect of the Market

If Federal programs, including those at the state and local level sponsored by the Federal government, account for less than 5 percent of the observed reduction in energy consumption per dollar of GNP, then the market must be responsible for the remaining 95 percent. Further, the apparent energy savings are significant, on the order of 12 quads. In this sense, the market has worked well, in both relative and absolute terms. Such savings could have been achieved only through a large collective response from millions of individuals. Price has undoubtedly motivated these actions and higher prices in the future will motivate even more.

In the context of the general discussion earlier, however, it is important to understand the specific nature of these actions. Some lead to fundamental improvements in energy efficiency, contribute to productivity, advance the Nation's economic growth and reduce future vulnerability to the negative impacts of embargo, disruption and energy price dictums. Others, however, force curtailment of energy use, depress labor productivity, aggravate inflation, change lifestyles, lower standards of living, cause severe deprivation in some segments of society and slow economic growth.

Knowing how much of each type of market response has taken place is relevant to the current debate because Federal programs which advance technology (such as research, development, demonstration and commercialization projects) and non-price market mechanisms which lower the price of capital (such as tax credits, financial incentives and direct assistance) are both targeted exclusively on promoting the first type of market response and obviating the second.

But what evidence is there to suggest how much of which is happening? The following paragraphs assemble some sketchy information on this question for each of three energy end-use sectors: transportation, residential buildings and industry.

In the transportation sector, some insight is gained by examining the case of the passenger automobile. Overall fuel consumption in 1980 was down 25 percent from a level that would have occurred had both travel behavior and automobile

technology remained same as in 1973. For 1980 data, the breakdown is as follows:

Decrease in auto travel	9.6	percent
Decrease in travel speed	1.6	percent
Decrease in vehicle size (interior volume)	1.8	percent
Technology Improvements in car MPG	10.2	percent
Improved driver technique and owner maintenance	1.3	percent
Total Reduction below 1973 base case	24.5	percent

Of this breakdown, technology improvements in car MPG (miles per gallon) and better maintenance (tune-ups, tire pressure monitoring, etc) account for about one-half of the observed market response. The rest may be attributed to decrease in travel (reduced service), decrease in travel speed (substitution of personal time for energy) and decrease in vehicle utility as measured by interior volume (smaller cars).

In the residential area, energy consumption per household was about 12 percent lower in 1980 than it was in 1973. This is a significant change, but it is short of the 30 to 50 percent reduction DOE estimates is achievable -- with no decrease in services or comfort provided -- through cost-effective investments, averaging $2000 per household. Moreover, the 12 percent reduction appears to have been achieved largely by curtailment actions, rather than by investments in efficiency.

In gas-heated homes, for example, consumption for space heating was calculated by the American Gas Association to have been about 12 percent lower for the period 1972-1978 than for the period 1967-1972. AGA concluded that a large and variable behavioral component was involved, and that very little investment in retrofit had occurred.

AGA's conclusion is corroborated by other sources. Oak Ridge analysts, using EIA data, found that in 1977-1978 more than half of the U.S. households took no retrofit action. Similarly, IRS data show that only 7.8 percent of all households took advantage of the tax credit for residential conservation measures in 1978; the comparable figure for 1979 was 6.1 percent. The average investment claimed by these taxpayers, furthermore, was about $700, or about one-third the recommended level.

Together, these findings suggest that behavioral actions of a curtailment nature have dominated the residential sector's market response. The fraction of total savings attributable to investment in retrofit over the last seven years is certainly less than 40 percent and may be less than 20 percent.

In the industrial sector, 1980 energy consumption per unit of output (value added measure) was down more than 17 percent from that of 1973 base year efficiencies. Of this, the breakdown is estimated as follows:

Shift in output mix	8.0	percent
Continuation of 1954-1973 trends	6.7	percent
Accelerated improvements in energy efficiency	2.7	percent
Total reduction below 1973 base case	17.4	percent

The first category is a shift in structure of industrial sector output away from energy-intensive industries toward lighter manufacturing. This is believed to have been exogenously imposed on the sector by changing consumer demands away from energy-intensive goods they can no longer afford. The second is improved energy efficiency due to the addition of modern and more efficient facilities under normal growth conditions. These gains are consistent with long-term trends, even in times of declining energy prices. The third is accelerated energy efficiency, above and beyond normal trends, resulting from investment induced by higher prices.

The price induced response, therefore, is estimated to be that of the changed output mix, plus any accelerated energy efficiency improvements observed since energy prices began to rise sharply in 1973. Of the total market response in the industrial sector, less than one-fifth (2.7 percent of 17.4 percent) is attributed to accelerated investment in energy efficiency improvements.

Summary of Market Effects

In summary, the market has responded strongly and, perhaps, predictably to higher energy prices. It has not necessarily responded optimally from a policy point of view. Energy consumption has been reduced by as much as 12 quads from 1973 base year efficiency levels. This response is dominated by price-induced behavioral actions of a curtailment nature: reduce driving, lowered thermostats, non-heated rooms, changing consumer demand for industrial output and others. It has also depressed labor productivity, lowered standards of living, changed lifestyles, slowed economic growth, aggravated inflation, and caused severe deprivation in some segments of society. This type of market response can be expected to prevail for some time into the future and will likely become more prevalent as prices continue to rise faster than income.

The large reductions in energy use per unit of GNP are not the result, primarily, of investments in technology. Of that portion of energy savings attributed to increased price, less than one-third and, perhaps, less than one-fifth, is due to investments in improved energy efficiency. Of these investment-type of responses, turnover of stock in the passenger automobile fleet and additions of new plants in industry appear to have contributed the most so far to improved energy efficiency; retrofit in industry and housing, the least.

Future Effects of Eliminating Federal Programs

In the longer-term, although not yet apparent from the experience of the last seven years, curtailment may give way to investment. Investment in new technologies and turnover or modernization of capital stock are inherently much slower phenomena than sudden decisions to simply do without. It should not be unexpected, then, that investment has had the lesser effect on the whole to date.

If high interest rates on capital prevail, however, investment in energy efficiency improvements will proceed even more slowly. Acceleration of investment, consequently, may be desirable. It has been linked to economic revival, improved labor productivity and the return to rising standards of living. If such arguments are convincing, then policy mechanisms could be installed in ways that are most effective for each sector or activity in the economy. Non-price market incentives such as investment tax credits and accelerated depreciation allowances, may be appropriate for some sectors. Federal programs, rather than market incentives, may be more appropriate in others, particularly in the areas of identified market failures or where tax-related incentives are not applicable.

If acceleration of investment is an objective, then presumably the best ways of achieving it can be found. Increased energy prices are beneficial means toward this end. Tax credits, if one believes the Treasury analysts, would appear to be somewhat ineffective, having low leverage (1:1 or 2:1) on incremental private investment per Federal dollar. Some DOE programs, if one believes the DOE analysts, would appear to be much more effective than tax credits, having higher leverage ratios, 5:1 or better.

While DOE programs have had little apparent effect on national energy consumption to date (less than 5 percent of observed savings), primarily for reasons of focus in time and purpose, they may have had a larger effect on investment. DOE's programs have focussed primarily on investment, hence, whatever

impact they might have had on the whole may be attributed primarily to the investment portion. If the investment response is less than one-third of the whole, DOE's 5 percent of the whole may actually be 15 percent of the one-third.

A national energy conservation based solely on price, or on both price and non-price market incentives combined, without Federal programs, will likely reach a large and significant audience of potential respondants. The future effects of such a policy, however, are difficult to know. In general, the extent to which capital investments can be encouraged as energy prices rise, the more rapid the transformation of existing capital stock to new optimums and the less difficult and prolonged the period of adjustment.

The existence, or lack thereof, of Federal programs targeted on this objective can have a measurable effect on the rate of private investment. Whether or not Federal programs are advisable would appear to depend more on the issue of market failure and need, rather than on the issue of effect or effectiveness. If Federal action of one form or another is desired, then a subsidiary issue becomes important, that is, determining which programs or measures are more effective than others, per dollar of Federal outlay, whether they be program budget items or "tax expenditures."

Lastly, the marketplace is now in transition. Energy prices, in particular, have risen dramatically again in 1979 and 1980, oil has been decontrolled and natural gas price controls are gradually coming off. It is difficult to know whether market failures in the past will continue to be market failures in the future. Clearly, however, a thoughtful understanding of the market, its responses to price, its strengths and weaknesses, is a fundamental prerequisite to policy analysis. To this end, these issues should have priority on any analytical agenda for the coming year.

Mr. FUQUA. Yes; I think that has already been submitted.

Ms. SCHNEIDER. All right. If not, I would like to submit it.

Mr. FUQUA. I am advised that it has not been submitted.

Ms. SCHNEIDER. All right.

I have another question on photovoltaic technology. The Jet Propulsion Laboratory indicates that the Japanese have budgeted $60 million for photovoltaic development in their 1982 fiscal year, and they have some increases planned for their 1983 budget.

I wonder if you can tell us what the 1983 budget is proposing for photovoltaic work here in the United States?

Mr. TRIBBLE. It is $27.6 million.

Ms. SCHNEIDER. All right. This is a cut of how much?

Mr. TRIBBLE. The fiscal 1982 number was $78 million.

Ms. SCHNEIDER. But you had originally a request to OMB for $48 million for photovoltaics. Is that correct?

Ms. TRIBBLE. Just a minute. Let me see.

Ms. SCHNEIDER. All right.

Mr. TRIBBLE. The request to OMB by the Department was $33 million.

Ms. SCHNEIDER. And how much did you originally request from Mr. Edwards?

Mr. TRIBBLE. We requested $48 million.

Ms. SCHNEIDER. Well, it seems to me that we have come a long way since the original request of $48 million. Can you tell me what the justification was for such a decrease?

Mr. TRIBBLE. Apparently, it was priority of other items that I am not aware of.

Ms. SCHNEIDER. Well, we had Mr. Edwards before this committee the other day, and he expressed a strong desire that the United States not lose their edge in the international market.

Just to be empharic about this, I would like to share with you how the United States is losing its edge. I will tell you that very shortly we will be buying photovoltaic cells from the Japanese. However, I have here a solar calcular that is manufactured by Toshiba. Moreover, Texas Instruments also has put out a solar calculator, but I will tell you that on the back of this Texas Instrument calculator it says "made in Japan." I think that, pretty clearly exemplifies how the United States may be giving up our investment in research and development in a technology that based on all indications, seem to be right on the brink of moving ahead in the international market.

I, for one, find it regrettable that when we are so close to that point that our budget doesn't reflect that as a priority item.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Ms. Schneider.

Mr. Fish?

Mr. TRIBBLE. Mr. Chairman, could I respond to that for just a moment?

Mr. FUQUA. Certainly.

Mr. TRIBBLE. This is an important area, and I would like the committee to have some information relative to the activity that is taking place in the photovoltaic industry.

In 1981, sales of photovoltaic arrays and systems were estimated at $75 million which is a 50-percent increase over 1980. Industrial

investment in development, production, automation, and expansion exceeded $100 million. One firm by the name of Solarex plans a 6-megawatt photovoltaic plant for startup in September 1982. Atlantic Richfield Co., has invested in one of the largest single-crystal silicon cell production facilities. There are a number of other—I have a whole page full—developments that are taking place in the photovoltaic industry in the United States.

Certainly, we have to recognize that the Japanese are working very much on this technology. They are tough competitors, but I don't think that we need to yield to them. They have some innovative—as you just point out—means of supporting their technology.

Our technology is moving forward also.

Mr. FUQUA. Mr. Fish?

Mr. FISH. Thank you very much, Mr. Chairman.

Mr. Secretary, I welcome you with us again. If I could follow up on a couple of points made by my colleage from Rhode Island, on the question of information dissemination, you said that the Franklin Institute was now the place that the public communicates with for information. Is it the old National Solar Heating & Cooling Institute?

Mr. TRIBBLE. Is that what it is? I know it is the Franklin Institute.

Mr. FISH. Now, does that replace what we had in place which was the Residential Conservation Service, the Regional Solar Energy Centers, and the Energy Extension Service?

Mr. TRIBBLE. No; it doesn't replace them.

Mr. FISH. Well, are they still in existence?

Mr. TRIBBLE. No; the Regional Solar Energy Centers are being phased out. They have been given instructions to turn in the contracts that they have ongoing. They have been evaluated. Some have been told to continue to a logical termination point.

Generally, what is being done there is to move to phase out this operation.

This part of the information dissemination activity consisted largely of working through State energy offices and through local organizations such as through local chambers of commerce and things of that nature for energy conservation seminars and things of this nature. A lot of that type of work is being phased out.

The work that is being going forward at the Franklin Institute has been primarily inquiries or answering inquiries that could be answered by a telephone call or simply the insertion of a leaflet in an envelope and mailed back to them.

Mr. FISH. I guess, Mr. Tribble, my point is that a couple of years ago I remember being critical of the fact that you had the National Solar Heating and Cooling Center, the Residential Conservation Center, Regional Solar Energy Centers, and the Energy Extension Service. There were so many centers that it would be confusing to the average person or builder who wanted information on various solar applications I always thought that these centers could be consolidated.

My questions relates to whether the Franklin Institute is the successor to all of these centers? Is it broadly known across the land that you can call an 800 number or drop them a line, that

they will be able to answer your question whether you are a professional engineer or a homeowner?

Mr. TRIBBLE. They would be more in the category of in the position to answer the question of the homeowner. They do not supply technical reports. Those are available generally through SERI or through the National Technical Information Service.

As we gather additional data and finish the reports on the demonstration programs that we have had in effect, we will publish a final report on each one of these and make it available to the people who have use for it.

However, the Franklin program is not one that would change in its nature. It would continue to be merely responsive to inquiries that could normally be answered by putting a leaflet in an envelope.

Mr. FISH. The gentlelady from Rhode Island was talking to you about improved energy conservation and in particular improved energy combustion. Isn't it so that what you are conducting today is limited to basic or generic research versus the interest this committee has had in the past in the area of applied technology development?

Mr. TRIBBLE. Yes.

Mr. FISH. Well, can you tell me—because this is within your jurisdiction—what is being done in the transportation sector to hopefully see improved combustion?

Mr. TRIBBLE. There are a couple of programs going on with the building of a gas turbine for automotive use. This has been an ongoing program for several years. It has reached the point—it will reach the point this year--that there will be prototypes of two different designs that will be tested on a dynamometer.

These prototypes will be all metal. In order for the efficiency for a gas turbine to be improved, we will have to go to higher temperatures in the turbine section. There is an ongoing research program in ceramics to fabricate and install ceramic components so that we can go on up in higher temperatures in these parts of the turbine. It will enable us to increase the efficiency.

There is some additional work that has been done on a sterling engine which is an engine quite different from any that are now in common usage. We are proposing that work be phased out for many reasons. However, this work has been going on in the transportation sector.

In addition to that, we have had the ongoing program for the development of electrical vehicles. Electrical vehicles are, as a matter of fact, available in the marketplace. Therefore, our activity is no longer going toward the development of a vehicle as a vehicle, but to continue to do work in battery technology and propulsion technology.

Mr. FISH. Mr. Secretary, does your department actually plan to put these ceramic parts in the gas turbine proof-of-concept engine?

Mr. TRIBBLE. This has been a cost-shared activity between some of the industry and DOE. What we would hope is that we could go forward with the research into making the ceramic parts, and that as they are cost-shared activity, they would be willing to put them into an engine and test it.

Mr. FISH. You are cost-sharing with an industry on a company-by-company basis losing a $1 billion. Do you think they are in a position to take over half of the work?

Mr. TRIBBLE. They are putting a little bit into the program, not a great deal. However, since the engine is built, this would not entail a great deal of cost.

Mr. FISH. If I could turn to another subject, I have heard that the administration wants to repeal the small hydropower tax credit. Is that true?

Mr. TRIBBLE. Mr. Fish, there are a large number of those tax credits that have been mentioned for repeal. I am sorry that I can't answer you definitively on that particular one. I would think that it would be repealed as it applies to businesses because of the accelerated-depreciation provisions of the 1981 tax bill, thus giving an opportunity for a business to make an investment and get a rapid writeoff.

Mr. FISH. Well, there are lots of other questions, but with the chairman's indulgence, I would like to get into one we haven't mentioned, and that has to do with the Department's manpower resources. I am talking about manpower available to carry out the Department's responsibilities for the current fiscal year that we are in. We have received reports indicating that many key personnel are now leaving the Department. My question to you is, Do you believe that there are adequate manpower resources in the Department to effectively carry out your program requirements for this fiscal year?

Mr. TRIBBLE. Yes, I do.

Mr. FISH. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Fish.

Mr. Weber?

Mr. WEBER. Thank you, Mr. Chairman. I guess we are running a little bit short on time.

Mr. FUQUA. The gentleman's assessment is correct.

Mr. WEBER. Yes. My message is about the same as I delivered to Secretary Edwards, Mr. Tribble, but I guess I will ask you the same thing.

In your opening statement, again, you say, as everybody from the Department in concert tells us, that this budget reflects the need to minimize Government intervention in the marketplace.

What do you define in terms of Government intervention in the energy marketplace?

Mr. TRIBBLE. Subsidization of fuels so that the market sends inaccurate signals to the consumers. For example, for many years, the price of gas and oil was controlled at a level where there was little incentive for industry, for example, to build energy-efficient equipment.

Mr. WEBER. I understand that. Would you not say that what is happening in the State of Washington today in our nuclear power program is a result of precisely what you just said: Government subsidization leading to inaccurate signals being sent to power consumers in that State?

Mr. TRIBBLE. I wish you would elaborate a little bit. I am not sure.

Mr. WEBER. The problem that the Washington system is having is that nuclear powerplants are being cancelled out there and the ratepayers' bills are possibly going to be forced way up in order to pay for nuclear powerplants that are not going to be built?

If you are not familiar with it, I won't belabor the point, but it seems to me that that system is an example of Government interference in the marketplace causing just some of the kinds of problems that we as free marketers would be concerned about.

Mr. TRIBBLE. If I understand that, that was a consortium of the utilities in that area that did get together to build these stations.

Mr. WEBER. That is correct.

Mr. TRIBBLE. They did this on the basis of an anticipated future need. They, unfortunately, did run into the regulatory morass that has increased their cost manifold and other cost delays.

Mr. WEBER. But they were also built based on a subsidy really to a nuclear energy industry which goes back to the 1950's, shall we say, in terms of research and development moneys. We can belabor the point forever, but my problem with your position and the problem that I have with the whole DOE budget—and, frankly, the reason that I think your department is in so much trouble with its budget—is that you are trying to justify to this committee the elimination or substantial reduction of subsidies which are very minor compared to the subsidies that have gone into other forms of energy.

The conservation renewables programs have only been on the books for 5, 6, or 7 years. Subsidization of nuclear energy goes back to the 1950's.

I just will say, as I told the Secretary, I think you have difficulty, and I think the administration is going to have difficulty, having any credibility for the numbers that you present to us as long as you are going to continue to try to use the rationale which really doesn't make any sense.

You know, if you want to come up here and say: "We don't think that the Government should subsidize conservation and solar, but we do think they should subsidize other forms of energy because we want to manipulate the marketplace in a different direction than the past administration," I might not agree with that, but that is honest.

However, that is not what you are telling us: Instead, you are telling us: "We want to pursue a free- market policy, but only when it affects those technologies which we decide we don't want to subsidize." That is just not honest, and it doesn't make any sense, so nobody really buys it. I don't know why you continue to come up here and give us that kind of rhetoric.

Mr. TRIBBLE. As I have said earlier, I am not in a position to influence what is done in the nuclear area.

Mr. WEBER. Well, all right. I understand that. I will ask the same thing I asked the Secretary.

Mr. TRIBBLE. Yes.

Mr. WEBER. I wish that you would refrain from using free-market rhetoric in defending the DOE budget because some of us were elected on a platform that talks about free market in energy, and you are forcing us to find different rhetoric because that isn't what this is.

Mr. TRIBBLE. I am sorry.

Mr. WEBER. Thank you. I suppose we better go.

Mr. FUQUA. Thank you very much, Mr. Weber. I wish we had more time, but we have exhausted our time, and we do have a vote on the floor.

We do want to thank you, Mr. Tribble and your associates for being here with us this morning.

The next hearing will be on Thursday at 2 in this room. The subject is conservation and renewable energy. We will hear from public witnesses.

The subcommittee stands adjourned.

[Whereupon, at 1:05 p.m., the subcommittee was adjourned, to reconvene at 2 p.m., on Thursday, March 11, 1982.]

1983 DEPARTMENT OF ENERGY AUTHORIZATION

THURSDAY, MARCH 11, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 2:04 p.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, Fish, Dunn, Gregg, Wolpe, Schneider, and Sensenbrenner.

Also present: Martha Krebs, staff director; Dr. Eugene Frankel, science consultant; and Daniel Steinway, minority counsel.

Mr. FUQUA. The subcommittee will be in order. Today we will hear from outside witnesses on the Department of Energy's conservation research, development, and demonstration programs.

We have been trying for more than a year to get hard data from DOE on the ability of private industry to pick up R. & D. activities currently funded by the Department. Secretary Edwards tried to shed some light on this issue at our hearing last Thursday. He cited the circline light bulb and the heat pump water heater as examples of private sector activities in the conservation area.

However, he failed to note that these products were completely developed and demonstrated by DOE. They were only picked up by the private sector after the DOE R.D. & D. activities were successfully terminated. Under current DOE guidelines, these two successful products would have never been developed.

I have received copies of 36 letters by industry and university participants in the DOE industrial energy conservation program. In general, these letters strongly support the program and indicate that the R. & D. it sponsors would not go on without DOE support. I would like to read from one of the letters which is especially eloquent. The author is Willard Sawyer, director of biomass conversion of Gorham International, Inc., of Portland, Maine.

I quote from the letter:

> I have been reading the papers and watching the news on TV. The message is clear: cut-cut-cut out Federal programs, grants, projects, and now I hear even ongoing contracts are being terminated. If contracts like Gorham's IFD project are to be cut off, how are the wide-ranging benefits this project will produce going to be accomplished?
>
> The 500 million barrels of oil per year which forest residues represent can start replacing oil as soon as 5 years from now if this project goes full term, but if funding is cut off now, who is going to pick up the project and bring it to conclusion?

Before Gorham ever asked for DOE support, we sent proposals to all major pulp and paper companies, engine manufacturers, boiler companies, and certain other energy-intensive companies. We got a better than average response: all negative. When asked why support was not available, a few were willing to bluntly say, "What's in it for us—us exclusively. Before we can support a risky research project like drying forest residues in the forest, we would have to see an exclusive advantage. Our money cannot support projects that benefit everyone. They have to benefit us first, most, and hopefully exclusively."

Gorham International would benefit exclusively if it could raise the money to fund this project itself, but it cannot. The risk is too high for banks to help and Gorham is not a capital-intensive business. We have only meager assets on which we can borrow money. Our major asset is brain power, and you cannot use that at the bank.

The situation is worse now than it was when industrial support was first sought. Gorham has spent what it could on this project already. Industry prospects for support are less bright than when we sought support previously. In my judgment, we would stand even less chance of gaining support for industry now. State funds have dried up also. The only people I see that would be interested in converting forest residues into a form more suited to long distance transport are the Japanese. They are constantly asking for more information about this project. That is not where this fuel and feedstock resource ought to go. It needs to be used in these United States to help our own energy situation. In a nutshell, if Federal money is shut off, this support will die.

[The opening statement of Mr. McCurdy follows:]

OPENING STATEMENT OF REPRESENTATIVE DAVE MCCURDY—EDA SUBCOMMITTEE ON INDUSTRIAL ENERGY CONSERVATION

Mr. MCCURDY. Mr. Chairman, I want to extend a very warm welcome to Dr. William Kirsch, the director of the Center for Energy Management and Economic Development at the University City Science Center in Philadelphia. One of the six energy analysis and diagnostic centers he directs is at Oklahoma State University. I want to congratulate and compliment Dr. Kirsch and Dr. Wayne Turner, the director of the Oklahoma Center, for the sound energy management they have provided to small- and medium-sized manufacturers. Between 1976 and 1979, the EDAC's throughout the country have identified $3.2 trillion Btu's per year of energy conservation opportunities. The overall implementation rate has been 58 percent and the average rate of return on industry's investment in energy management and conservation has been 238 percent. Not only have the EADC's helped small businessmen and reduced energy consumption, they have also provided the Federal Government with increased tax revenues; implementation of EADC recommendations has increased profits to the point where the Government receives a 121-percent return on its investment.

DOE has requested no fiscal year 1983 funding for the energy analysis and diagnostic centers. In fact, the fiscal year 1983 budget contains no funds for the Office of Industrial Programs. There is no one in the private sector who is fulfilling the energy management needs of the small- and medium-sized manufacturer and it seems shortsighted and unwise to eliminate a program that benefits not only industry and the Federal Government, but also improves energy efficiency and promotes energy conservation. I urge my colleagues to look closely at the cost effectiveness and success of the EADC's and to consider restoring adequate funding to this important energy management and conservation program.

Mr. FUQUA. Our first panel today will deal directly with the industrial energy conservation program and the likely consequences of its termination. Panelists will address the issues of foreign competition, benefits of the program, and the private sector's incentives to carry out the needed research and development on its own.

Our first witnesses are Mr. Henri-Claude Bailly of Hager-Bailly & Co.; Mr. Robert Lawrence of Mechanical Technology, Inc.; Mr. William Kirsch of the University City Science Center; and Mr. Donald Jorczak of Dresser Industries.

We would like to ask these gentlemen to come forward.

I might point out for our witnesses and also for the members of the committee that we also have another panel of four people following this. In order to finish before the Sun sets, I would like to ask the members to ask a minimum of questions if they can. I would also like to ask our witnesses to summarize their statements if that would be possible. If you have a printed copy of it, we will make that part of the record in its entirety. If you wish to summarize, it would be greatly appreciated.

STATEMENT OF HENRI-CLAUDE BAILLY, PRESIDENT, HAGLER-BAILLY & CO.

Mr. BAILLY. I am Henri-Claude Bailly, president of Hagler-Bailly & Co. Our firm assists executives around the world to deal with changing energy and natural resources markets.

I am keenly interested in the Department of Energy's industrial energy conservation program because, since its inception, this program has constituted the only direct U.S. Government support of R.D. & D. aimed at improving the productivity of industrial processes.

When I first came to the United States, about 14 years ago as a graduate student, U.S. technological and industrial leadership in the world was at its peak. Since that time, I have witnessed the slow but sure erosion of many of the U.S. manufacturing sector's basic segments. My concern is that without continued direct support of R.D. & D. by the U.S. Government, the United States will be unable to halt that erosion and regain its technological and industrial leadership.

As a result, when advanced technologies are needed, they may well come from abroad, allowing foreign companies to capture a substantial share of what is becoming a multibillion dollar domestic market.

Today I would like to address two arguments that are often advanced to justify the elimination of direct Government support for industrial energy conservation R.D. & D. The first argument contends that higher energy prices, coupled with the incentives of the Economic Recovery Tax Act, which was passed last August, will provide enough inducement for the private sector to develop new, high risk—and I emphasize the new, high-risk aspect—of these technologies. The second argument contends that the possible need to import these technologies is not sufficient ground for Government support.

According to the first argument, market pull will be sufficient to stimulate investment in new technologies. Recently, we, Hagler-Bailly & Co., conducted an analysis, with the assistance of one of our outside consultants, of the financial returns associated with the development of four new high risk or risky technologies. One was a slow-speed diesel engine for cogeneration. The others were an electric-driven Rankine vapor compression heat pump; a ceramic recuperator; and a new type of metallic recuperator.

We selected these technologies because they vary widely with respect to their probability of failure—from about 15 percent in the case of the slow-speed diesel to 70 percent in the case of the ceram-

ic recuperator—and also because these technologies have a wide-ranging potential market.

Mr. Chairman, I would like to submit for the record a copy of the report summarizing in detail the methodology and the analysis which was actually conducted.

Mr. FUQUA. The committee will take the report, and we will put it in part of our files relating to the hearing.

Mr. BAILLY. Thank you very much.

Without going into any detail, I would like to summarize for you the finding of our analysis. The incentives offered by ERTA—by the Economic Recovery Tax Act—will not—I repeat not—provide industry with sufficient incentives to accelerate R.D. & D. in new, high-risk technology designed to improve energy productivity. ERTA helps only slightly, but certainly not sufficiently, to increase and accelerate R. & D. development.

Additional Government support, such as Federal costsharing of development expenditure or higher tax credits, is needed to motive industry to accelerate R.D. & D.

The question, of course, arises: Why stimulate the development of these new, high-risk technologies if higher energy prices and existing tax incentives do not suffice? Let me answer this question by addressing the second argument generally advanced to justify eliminating Government industrial conservation R. & D. That argument is that U.S. companies should and must fend for themselves in a free market.

The theory of a perfectly free market, however, is only that—a theory. In practice, circumstances, both here and abroad, have acted to distort the competitive structure of the market. Government subsidy of R. & D. activities is one way in which the market is distorted. While the United States is eliminating or curtailing its direct subsidy of industrial energy conservation R. & D., many of our major trading partners are increasing theirs.

We recently completed a review of Government-sponsored, industrial energy conservation R.D. & D. activities in five developed nations: West Germany, France, Japan, Sweden, and the United Kingdom.

Again, Mr. Chairman, I would like to submit for the record a copy of this report that details each country's efforts in industrial energy conservation R.D. & D.

Mr. FUQUA. We will make that part of the files of the hearing also.

Mr. BAILLY. Thank you very much.

The bottom line of our review is that in calendar year 1982, this year, these five Governments will spend approximately $150 million on industrial energy conservation R.D. & D. I am talking only about research efforts, not efforts associated with providing grants or other financial low-interest loans, for example, to industry with the aim of improving industry efficiency.

The objectives of these five governments are very clear: to maintain the cost competitiveness of their manufacturing sector, and to help companies market their know-how and technologies abroad. The U.S. market is really the plum.

In the race for productivity improvements, we have estimated the U.S. market to be on the order of $80 billion over the next 10

years. It is not a negligible market by any standard, even though it represents only a small fraction of the projected total capital spending of the U.S. manufacturing sector in the 1981-90 period.

Unfortunately, U.S. technology suppliers in many sectors—not in all sectors but in many sectors—will be at a competitive disadvantage with their foreign counterparts for two key reasons. First, foreign suppliers have accumulated more experience and credibility primarily because industrial energy prices have traditionally been higher abroad than in the United States. The U.S. Government's past and continued intervention in the energy market is much to blame for our technological gap in some sectors. It is hard to blame U.S. industry for making what was a rational economic decision, given the cost it was paying for its energy.

U.S. technology suppliers are also likely to be at a disadvantage because foreign companies, particularly small- and medium-size enterprises, will continue to receive subsidies from their Governments to develop and market industrial energy conservation technologies. Indeed, the export potential is a criterion that is explicitly considered by many foreign governments in evaluating projects to support.

Let me give you a few examples of foreign programs to underscore the challenge. The Federal Republic of Germany provides subsidies for technical, economic, and organizational advice on improving energy efficiency. Like many German programs, the size of the subsidy depends on the size of the company. The Government also provides low-interest loans for energy saving and other investments aimed at improving process efficiency. Some 6.3 billion deutsche marks, equal to $2.6 billion at today's exchange rates, are available under this program. Firms with less than 50 million deutsche marks in revenues or sales can receive loans for up to two-thirds of their investments. The German Government also sponsors a program to accelerate the market introduction of energy-saving technologies. It provides up to 50 percent of the total cost of items such as engineering development, market planning, and even production line development. The repayment of these loans or grants may be totally or partially waived if product introduction is not successful.

France is providing up to a 25-percent grant for firms producing newly developed, energy-saving equipment. Demonstration projects are eligible for grants of up to 50 percent. The performance measurement campaign is paid in total.

The Japanese Government is increasing tenfold its conservation R. & D. support in 1982 for small- and medium-size businesses. The Government of Japan also sponsors a very extensive information audit and training program. By the end of last year, MITI had directed 4,200 Japanese businesses to appoint an energy control officer who was an individual certified in a nationally administered examination. This energy control officer, who is on the payroll of the company, is responsible for improving the efficiency of energy-using equipment and also for carrying out other duties as specified by MITI.

The British Government provides grants of up to 25 percent of the capital and installation costs for projects that demonstrate

either new or improved energy conservation technologies or new applications of established conservation technologies.

I could go on. The point is, Mr. Chairman, that the market does not operate freely. Believing in market laissez-faire will not enable U.S. companies to successfully compete. Instead, the U.S. Government must recognize and respond to the competitive strategies of other advanced industrial nations.

To sum up, the two arguments often advanced as grounds for eliminating Government support for industrial conservation do not appear valid.

The incentives of the Economic Recovery Tax Act are not sufficient to accelerate high-risk R. & D., and U.S. suppliers, particularly small- and medium-size companies, are definitely at a competitive disadvantage because the market does not operate freely.

The U.S. Government has a vital role to play in helping U.S. industry regain its technological leadership. Many of the research and development breakthroughs achieved in the past years have been the result of a Government-private industry partnership: the telegraph, the transistor, the laser, to name but a few that have become the basis for new multibillion dollar industries.

DOE's industrial energy conservation program has sponsored several major innovations that, if applied, will help some U.S. industries to compete more effectively. Until the free-market principles espoused by this administration are also embraced by our major trading partners, U.S. suppliers will need the support of their Government to remain competitive both here and abroad.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Bailly follows:]

Statement of
Henri-Claude Bailly
President
Hagler, Bailly & Company

FY1983 Authorization for the Department of Energy's
Conservation Research and Development Programs
March 11, 1982

* * *

Mr. Chairman, Members of the Subcommittee

I appreciate the opportunity to testify on the Department of Energy's Conservation Research and Development programs. I am H.C. Bailly, President of Hagler, Bailly & Company. Our firm assists executives around the world to capitalize on the opportunities and minimize the risks created by changing energy and natural resources markets.

I am keenly interested in DOE's Industrial Energy Conservation Program, which -- since its inception -- has constituted the only direct U.S. Government support of research, development, and demonstration activities aimed at improving the productivity of industrial processes. When I first came to the United States as a graduate student nearly 14 years ago, U.S. technological and industrial leadership in the world was at its peak. Since that time, I have witnessed the slow but sure erosion of many of the U.S. manufacturing sector's basic segments. My concern is that without continued direct support of RD&D, the United States will be unable to halt that erosion and regain its technological and industrial leadership.

As a result, when advanced techologies are needed they may well come from abroad, allowing foreign companies to capture a substantial share of a multibillion dollar domestic market.

Today, I would like to address two arguments that are often advanced to justify the elimination of direct government support for industrial energy conservation RD&D. The first argument contends that higher energy prices, coupled with the incentives provided by the Economic Recovery Tax Act (ERTA) of 1981, will provide enough inducement for the private sector to develop new, high-risk technologies. The second argument contends that the possible need to import these technologies is not sufficient ground for government support.

According to the first argument, market "pull" will be sufficient to stimulate investment in new technologies. Recently, we conducted an analysis, with one of our consultants, of the financial returns associated with the development of four new technologies -- a slow-speed diesel engine for cogeneration; an electric-driven Rankine vapor compression heat pump; a ceramic recuperator; and a plate fin metallic recuperator. We selected these technologies because they vary widely with respect to their probability of failure -- from 15 to 70 percent -- and their market potential. Mr. Chairman, I would like to submit for the record a copy of the report summarizing the methodology and assumptions used in this analysis. Without going into detail, let me summarize the findings.

The incentives offered by the ERTA will not provide industry with sufficient incentive to accelerate RD&D in new, high-risk technology designed to improve energy productivity. Additional government support -- such as federal cost-sharing of development expenditures or higher tax credit -- is needed to motivate industry to accelerate RD&D.

The question arises: why stimulate the development of these new, high-risk technologies if higher energy prices and existing tax incentives don't suffice? Let me answer this question by addressing the second argument generally advanced to justify

the elimination of direct government support for industrial energy conservation RD&D -- that U.S. companies must fend for themselves in a free market.

The theory of a perfectly free market, however, is only that -- a theory. In practice, circumstances both here and abroad have acted to distort the competitive structure of the market. Government subsidy of RD&D activities is one way in which the market is distorted. While the United States is eliminating its direct subsidy of industrial energy conservation RD&D activities, however, several of our major trading partners are increasing their subsidies.

We recently completed a review of government-sponsored industrial energy conservation RD&D activities in West Germany, France, Japan, Sweden, and the United Kingdom. Mr. Chairman, I would like to submit for the record a copy of the report that details each country's efforts in industrial energy conservation RD&D. In calendar year 1982, these five countries will together spend 147 times more than the United States on industrial energy conservation RD&D. Their objectives are very clear: to maintain the cost competitiveness of their manufacturing sector and to market their know-how and technologies abroad -- especially into the U.S. market.

In the race for productivity improvements, we estimate that U.S. industry will invest $80 billion dollars over the next 10 years just to cut energy costs. Not a negligible market by any standard, even though it represents only 4 percent of the projected total capital spending of the U.S. manufacturing sector for the 1981-1990 period. Unfortunately, U.S. technology suppliers in many sectors will be at a competitive disadvantage with their foreign counterparts for two key reasons. First, foreign suppliers have accumulated more

experience and credibility, primarily because industrial energy prices have traditionally been higher abroad than in the United States. The U.S. government's past and continued intervention in energy markets is much to blame for our technological gap in some sectors. It is hard to blame U.S. industry for making what was a rational economic decision, given the cost of its energy. U.S. technology suppliers are also likely to be at a disadvantage because foreign companies, particularly small and medium-size enterprises, will continue to receive subsidies from their governments to develop and market industrial energy conservation technologies. Indeed, the export potential is a criterion that is explicitly considered by many foreign governments in evaluating projects to support.

A few examples of foreign programs may serve to underscore the challenge. The FRG provides subsidies for technical, economic, and organizational advice on improving energy efficiency. The size of the subsidy depends on the size of the company. The government also provides low-interest loans for energy-saving and other investments aimed at improving process efficiency; DM 6.3 billion ($2.6 billion at today's exchange rate) are available under this program. Firms with less than DM 50 million in sales can receive loans for up to two-thirds of their investments. The German government also sponsors a program to accelerate the market introduction of energy-saving technologies and products, providing up to 50 percent of total costs (e.g., engineering development, market planning, production line development). Repayment may be totally or partially waived if product introduction is not successful.

France, for example, provides a 25-percent grant for firms purchasing newly developed energy-saving equipment. Demonstration projects are eligible for grants of up to 50 percent

of the total project cost and up to 100 percent of a total performance measurement campaign.

The Japanese government is increasing tenfold its conservation RD&D support for small and medium-size businesses. The government also sponsors an extensive information, audit, and training program; by the end of last year, MITI had directed 4,200 enterprises to appoint an energy control officer (certified in a nationally administered examination). These officers are responsible for improving the efficiency of energy-using equipment and carrying out other duties specified by MITI.

The British government provides grants of up to 25 percent of the capital and installation costs for projects that demonstrate (1) new or improved energy conservation technologies, including equipment and processes, or (2) new applications of established conservation technologies. As of August 1981, 129 projects were being supported.

The point is that the market does not operate freely. Believing in market laissez-faire will not enable U.S. companies to successfully compete. Instead, the U.S. Government must recognize and respond to the competitive strategies of other advanced industrial nations.

To sum up, the two arguments often advanced as grounds for eliminating direct government support for industrial energy conservation R&D do not appear to be valid.

- The ERTA incentives are not sufficient to accelerate high-risk R&D, and
- U.S. suppliers, particularly small and medium-size companies, are at a competitive disadvantage because the market does not operate freely.

The U.S. Government has a vital role to play in helping U.S. industry regain some of its technological leadership. Many of the R&D breakthroughs achieved in the past have been the result of a government/private sector partnership -- the telegraph, transistor, and laser, to name but a few that have become the basis for new, multibillion-dollar industries. DOE's Industrial Energy Conservation program has sponsored several major innovations that, if applied, will help some U.S. industries to compete more effectively. Until the free market principles espoused by this Administration are also embraced by our major trading partners, U.S. suppliers will need the support of the government to remain competitive both at home and abroad.

BIOGRAPHICAL SKETCH

Henri-Claude Bailly is President of Hagler, Bailly & Company, consultants to management on energy markets and technologies. Mr. Bailly pursues his activities on strategic market planning for both U.S. and foreign industrial companies. He has also consulted on international energy issues, particularly research and development issues, to numerous public bodies, including the EEC, UN, OECD, IEA, and DOE.

Mr. Bailly holds a BS in architecture and planning from the Ecole Nationale Superieure des Beaux-Arts in Paris, and a BArch and MArch from the University of Washington. He also has an MBA from the Harvard Graduate School of Business Administration.

GOVERNMENT-SPONSORED INDUSTRIAL ENERGY CONSERVATION RESEARCH, DEVELOPMENT, AND DEMONSTRATION

A review of programs in the Federal Republic of Germany, France, Japan, Sweden, and United Kingdom

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Introduction

Since the embargo of 1973/1974, and particularly since the oil price increases of 1979, the industrialized nations have focused increasing attention on ways of maximizing the return on their energy expenditures. Many nations have launched large-scale research, development, and demonstration (RD&D) programs aimed at improving the efficiency of energy use by all major consuming sectors.

Much can be learned by reviewing and analyzing foreign RD&D programs; in particular, such a review and analysis can provide a basis for directing and improving the cost-effectiveness of U.S. industrial energy conservation RD&D activities. Although a substantial amount of information has been gathered over the years, the existing international information base on industrial energy conservation RD&D is neither comprehensive nor specific enough to be useful to U.S. government decision-makers. To overcome these deficiencies and to provide information that is readily comparable with information available for U.S. activities, Battelle Pacific Northwest Laboratories retained Hagler, Bailly & Company to develop a data base on government RD&D activities and expenditures in industrial energy conservation. Five industrialized nations were selected for review: the Federal Republic of Germany, France, Japan, Sweden, and the United Kingdom.

This report presents the results of our work, which was carried out between June and November 1981. During the course of our effort, we reviewed numerous published and unpublished documents and interviewed representatives of many organizations -- public, quasi-public, and private -- involved in industrial energy conservation RD&D in each of the five countries. In total, the governments of the Federal Republic Germany, France, Japan, Sweden, and the United Kingdom plan to spend approximately $130 million on industrial energy conservation RD&D and related activities in calendar year 1981. U.S. government expenditures for 1981 are expected to total less than $32 million.[1]

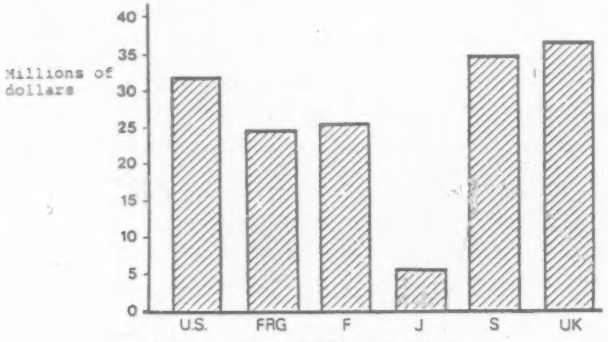
1. This figure is based on a budget of $43 million for FY 1981 (which ended on September 30, 1981) and no funding for FY 1982 (which started on October 1, 1981), as proposed by the Administration.

In reporting our results, we address only those program activities that fall directly within the purview of the U.S. Department of Energy's (DOE) Office of Industrial Programs (OIP). For example, in their industrial program, the Germans include RD&D activities in waste heat recovery from industrial sources for district heating applications. The Japanese industrial energy conservation program includes RD&D on high-temperature gas turbines aimed at large-scale power system applications. In both of these cases, we excluded these RD&D activities because they would be carried out by U.S. DOE divisions other than OIP. We have also normalized differences in fiscal years (e.g., the Swedish fiscal year starts in July, the British and Japanese in April, the U.S. in October, and the German and French in January); unless otherwise noted, we use calendar years to present all countries' expenditures. Exhibit 1 presents some key indicators of economic activity for each country; Exhibit 2 presents the foreign exchange rates used in this report.

International comparative statistics are always tentative because so many factors (e.g., definition of program activities, differences in fiscal years, actual vs. budgeted expenditures) come into play. Despite such uncertainties, we believe that three general conclusions can be drawn:

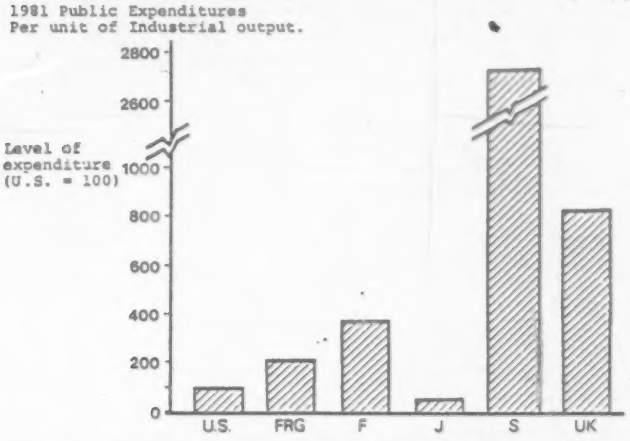
- The U.S. government will spend less, in absolute terms, on industrial energy conservation RD&D in calendar year 1981 than will Sweden or the United Kingdom. It will, however, spend more than the Federal Republic of Germany, France, or Japan, as shown below:

1981 Public Expenditures

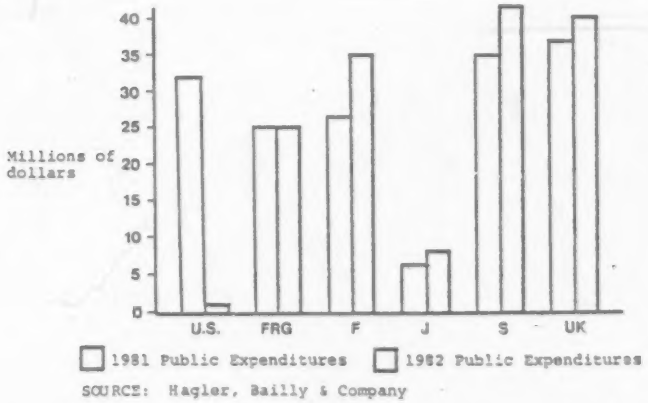


SOURCE: Hagler, Bailly & Company

- At the same time, the U.S. government will spend less than any one of the four European countries per unit of industrial output, as show below. Only the Japanese government will spend less than the U.S. government. (It appears, however, that Japan outspends every other country in privately funded industrial energy conservation RD&D.)



- Next year and beyond, all five countries studied will maintain or increase their government efforts in industrial energy conservation RD&D, as shown below.



SOURCE: Hagler, Bailly & Company

In addition to these three general conclusions, several characteristics common to the countries studied emerged from our review of industrial energy conservation RD&D policies, organization, and activities:

- Contrary to the view generally held in the United States, market laissez-faire has been the major policy instrument of most European countries and Japan; regulatory intervention in the industrial sector has been kept to a minimum (except in Sweden).

- RD&D, and particularly information and advisory programs, are considered integral and permanent components of each country's industrial energy conservation policy.

- Industrial energy conservation RD&D objectives and budgets generally cover multiple years (e.g., four years in Germany, three in Sweden, five in Japan).

- Government-sponsored industrial energy conservation RD&D is heavily oriented toward small and medium-size enterprises, particularly in Germany and Japan.

- European public sector industrial energy conservation RD&D is heavily oriented toward near-term marketability of results. The primary components of all projects are engineering development and commercial demonstration, rather than basic and applied research. This is not the case in Japan, however, where the government sponsors mostly long-term RD&D projects. In selecting projects for support, all countries consider export potential.

- Government RD&D activities in Europe are generally cost-shared with industry to ensure the earliest possible commercialization. Projects are seldom awarded on a competitive basis. In Japan, most RD&D is conducted by government research institutes.

- Industry participates, often through trade associations, in the definition of RD&D programs. In several countries, industry even participates directly in the selection of specific projects.

- Because several industries in Germany, France, and Japan are already among the most energy-efficient

in the world, the RD&D in these industries is shifting more and more toward the development of totally new technologies and processes (rather than components) to improve energy efficiency further. This shift will in all likelihood result in overall -- and not just energy-related -- productivity improvements.

In the remainder of this report, we detail each country's RD&D organization, major activities, and budgets. Each individual country report is supported by an appendix that provides additional information on particular aspects of that country's industrial energy conservation RD&D program.

Mr. FUQUA. Thank you very much, Mr. Bailly.
Mr. Lawrence?

STATEMENT OF ROBERT LAWRENCE, DIRECTOR, TECHNICAL DEVELOPMENT, MECHANICAL TECHNOLOGY, INC., ACCOMPANIED BY ROBERT S. KRIPOWICZ, PROGRAM DEVELOPMENT MANAGER, MECHANICAL TECHNOLOGY, INC.

Mr. LAWRENCE. Thank you, Mr. Chairman. My testimony will consist of two brief parts. I will give about the first 5 minutes, and relinquish this seat to Mr. Kripowicz who is with us who will give the second 5 minutes.

I would like to introduce the testimony, if I could, by reading a very brief introductory statement after which I will summarize the rest of my portion.

Mr. Chairman and members of the committee, I am Bob Lawrence, and I am director for technical development of MTI. With me today is Mr. Robert Kripowicz, our manager of program development. We appreciate the opportunity to come before you today to discuss the relationship between the DOE conservation technology programs and the Nation's needs in the areas of trade, energy, and productivity which are interrelated areas, obviously.

As you know, Mr. Chairman, MTI is a high-technology organization dedicated to evolving products in the residential, commercial, and industrial sectors from our strong technology core. We are an example of a small, aggressive company responsible for a large part of the industrial innovation which occurs in this Nation. We have been successful in commercializing our innovations to a significant extent, and we are most appreciative for the partnership we have had with the Federal Government in addressing those areas of high risk and high potential which fall outside the normal investment criteria.

The thrust of our testimony this year, Mr. Chairman, is along the theme of the energy productivity and trade problems that the Nation is facing today, and the relationship of the conservation technology programs to the solution of these problems.

The key question that we have asked ourselves this year is, Of all the industrialized countries, why does the United States place such a high priority on the budget deficit problem and such a low

priority on the balance-of-trade situation, whereas with every other industrialized nation of the world, those priorities are reversed. Balance of trade is an absolutely key high-priority item with budget deficit being secondary to that.

A potential answer, I believe, is found on the last page of my testimony which is a very simple figure which we have entitled the "Vicious Circle." The top of that circle is a good place to start and we can work around it looking at all the key items on that circle. As you will notice, on the top we are talking about industrial competitiveness. We can see that lower industrial competitiveness with foreign nations automatically leads to balance-of-trade deficits. Since we can compete less well, we get beaten in the marketplace. Balance-of-trade deficits means simply that cash flow goes to foreign industry instead of American industry. This means a lower gross national product as a result. Lower GNP means less money flow on which taxes are paid or lower tax revenues. Lower tax revenues, when compared to committed budget expenditures, simply lead to larger national budget deficits. Budget deficits, as we all know, lead to Government borrowing in the money markets increasing the demand for capital, resulting in higher interest rates. These interest rates, in turn, lead to lower capability for industry to invest in itself, leading to lower industrial competitiveness. It is a vicious circle.

The question is at what point on the circle do we attack the problem or do we just attack one point or should we attack several points on the circle?

If we take a look at how bad our balance-of-trade problem has now become in attempting to compete with foreign government industry teams, we find that, as I testified last year, from 1975 up through last year, that accumulated deficit was $127 billion. According to the National Association of Manufacturers, in the past year we have added another deficit of $27.6 billion to bring us up to $154.6 billion lost in balance-of-trade deficits since 1975.

Any other industrialized nation would look at this as some kind of horrifying effect, yet we seem to virtually put it aside and press on worrying about budget deficits which, from that vicious circle, you can see can be a direct result of our lack of international competitiveness.

Now I would like to move from that to our main subject of today which is these energy conversion technologies. We would like to submit that in this country a key core of capability to compete with foreign government-industry teams is these energy conversion technologies. It is a place where we have started to work the problem, where we are learning, in the commercial and industrial sectors. Government and industry teams can work together. We would like to submit that these things are terribly important to continue and to strengthen.

If I may, for your consideration at this time, bring to your attention a portion of the sunset review addressing the industrial energy conservation program, that portion is an extremely excellent delineation of the legislation that put these into effect, of the objectives, of the key criteria under which programs are selected, and the results of the programs.

If you believe it would be proper, I would like to submit this for the record or for the file, whichever you deem correct.

Mr. FUQUA. We will make it part of the proceeding.

Mr. LAWRENCE. All right, sir.

At this time, I am going to relinquish my chair to Mr. Robert Kripowicz who will discuss specifically those energy conversion technology programs.

Mr. KRIPOWICZ. Mr. Chairman, my name is Bob Kripowicz, program development manager for Mechanical Technology, Inc.

I would like to briefly review three reasons that I believe the Government-supported R. & D. program in conservation technology should continue.

The first reason is that industry is not likely to invest enough in this area itself. The investment horizon is short for industry, and long-term, high-risk R. & D. is not funded well by industry. Interest rates are high, making the cost of financing R. & D. high. Significant R. & D. takes place in small, high-technology firms which are least able to raise large amounts of funds. Energy-intensive industries are among the most depressed, examples of those being automobiles and housing. Many energy savings are not directly related to end-use products or product improvement which is where most industries spend their money.

The second reason is that the current program has been reasonably successful. Why stop a success? Several products or technologies have been introduced successfully to the marketplace, and several demonstrations are about to occur. Few of these would have occurred as quickly without Government support, and some might not have happened at all.

The third reason is that it is a relatively cheap insurance policy. A Government program assures that innovation takes place. One does not have to rely on the questionable premise that industry will do it all. The fiscal year 1982 program, for example, including previously deferred funds for the buildings, transportation, industrial, and advanced conservation R. & D. programs, is less than $150 million. That is less than two-tenths of 1 percent of our yearly oil import bill. It is less than the cost of a day's oil import, and it is much less than some other nations proportionately provide to their industry. It also has a much higher costsharing by industry.

In prosperous times, with low interest rates, high-capacity utilization, and high profits, industry might do all of the high-risk, long-term R. & D. necessary. In times like this, that does not seem likely. We are also competing not just with other industrial firms, but with other governments as well.

Therefore, I believe that Congress should continue, with the active support of this committee, to provide funds for long-term R. & D. projects in conservation in order to accelerate domestic development of efficient technology to reduce our dependence on foreign energy sources.

Thank you.

[The statement prepared by Mr. Lawrence and Mr. Kripowicz follows:]

House of Representatives
Committee on Science and Technology
Subcommittee on Energy Development and Applications

Hearings on DOE Conservation Program

March 11, 1982

Prepared by:
Dr. L.R. Lawrence, Jr.
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and
Mr. Robert S. Kripowicz
Program Development Manager

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About the Author . . .

Dr. L. Robert Lawrence, Jr.

Dr. Lawrence is Director of Technical Development for Mechanical Technology Incorporated (MTI). In this position, he is responsible for long-term corporate planning with primary emphasis on synfuels, Stirling engines, Rankine Cycles, heat pumps, and waste heat utilization. He is actively involved in the development of new markets for high-efficiency, high-reliability equipment. Prior to his present position, Dr. Lawrence was Director, Energy Conservation Research with the Gas Research Institute where he was responsible for the Gas Industry's program addressing the improved end-use of natural gas. He has been an executive with the Energy Research and Development Administration and with the Air Force Office of Scientific Research. In 1974, he was an Air Force Nominee for America's Ten Outstanding Young Men of the Year. He holds a number of professional memberships and has numerous technical publications.

Testimony of

Dr. L.R. Lawrence, Jr.

and

Mr. Robert S. Kripowicz

Mechanical Technology Inc.

Latham, New York

Subcommittee on Energy Development & Applications

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Hearings on DOE Conservation Program

March 11, 1982

Mr. Chairman, and members of the Committee. I am Dr. L.R. Lawrence, Jr. and I am Director for Technical Development of MTI. With me today is Mr. Robert Kripowicz, our Manager of Program Development. We appreciate the opportunity to come before you today to discuss the relationship between the DOE Conservation Technology programs and the nation's needs in the areas of trade, energy, and productivity. As you know, Mr. Chairman, MTI is a high-technology organization dedicated to evolving products, in the residential, commercial and industrial sectors, from our strong technology core. We are an example of a small (1000 people) aggressive company responsible for a large part of the "industrial innovations" which occurs in this nation. We have been successful in commercializing our innovations to a significant extent, and we are most appreciative for the partnership we have had with the federal government in addressing those areas of high risk and high potential which fall outside the normal corporate investment criteria.

To introduce my testimony today, Mr. Chairman, I would like to quote from a couple recent sources. The first is a book by Richard Bolling and John Bowles entitled **America's Competitive Edge**. It is based on a conference which took place in late April 1980, of about 150 people, at Harvard University to discuss

the nation's declining economic position at home and abroad. It included members of both the Senate and the House, senior business executives, academics, and a few representatives of labor. It was the conclusion of this assembly that America's future rested on our degree of success in three related areas: trade, energy, and productivity. This shouldn't be terribly surprising, considering the mountains of testimony presented before this Committee on these same subjects. In the arena of energy, the conclusions were:

> "It would include a major effort to export coal..." but "it would involve more than coal exports alone... The coal-technology innovations... should be exportable... Our coal program should be a coal-technology program."

and continuing:

> "We must also continue to encourage the unexpected breakthrough with a continual serious commitment to research and development. While an immediate solution should not be anticipated, long-term basic research in solar energy and other presently untapped, available sources should continue to be vigorously pursued. We cannot overemphasize the importance of research and development and the long-term need to diversify energy supply...and...we must continue to reduce demand for energy through programs for more fuel-efficient transportation, housing, and manufacturing plants and equipment."

Another article recently written by Robert Dale Shriner of Chase Econometrics, entitled "R&D - Are We Losing Out," states:

> "The competitiveness of U.S. industry in international markets depends greatly on our effectiveness in creating new and improved products to meet changing needs and to enhance the productivity of existing resources. Research and Development activities provide the foundation for our future competitiveness. However, the U.S. investment in nondefense R&D has stagnated, while the share of

national output devoted to nonmilitary R&D in other industrial nations has risen."

Further:

"Increased federal spending for defense R&D, while essential for maintaining our defense capabilities, conflicts directly with our ability to remain economically competitive with the rest of the world. Faced with an already short supply of well-qualified scientists and engineers to staff its R&D needs during the eighties, U.S. industry is likely again to find itself competing with defense and paying a higher price for both personnel and equipment than would have been the case if the level of defense and space spending had remained stable. The result is almost inevitably going to be a reduction in the amount of R&D actually obtained by U.S. industry."

and finally:

"Acceleration of U.S. industrial R&D is both essential and extremely difficult. The high rates of R&D spending achieved by other countries--most notably Japan and West Germany--reflect a major commitment by those nations to invest in the long-term technological competitiveness of their economies. We must develop a similar commitment, along with the institutional mechanisms to match their achievements, if we are to maintain our own competitiveness. That will require a degree of social and political innovativeness, and a long-term perspective, that have long been absent in U.S. labor, government, and industry".

Last year at this time, I testified on our international competitiveness pointing out that the balance of trade deficit since 1975 had totaled $127B. The National Association of Manufacturers puts the 1981 trade deficit at $27.6B. Therefore, the running total this year is $154.6B in trade deficits since 1975. Unfortunately, this has been largely ignored because the Current Account (money entering the country vs. money leaving the country) has remained balanced. The

reason for the balance, however, is that the money being lost to this country in trade deficit is returning as foreign investment such as ownership of assets which were previously ours. This now has the Defense Department worried about percentage of foreign ownership of key defense contractors.

The main fear I have, Mr. Chairman, is that we will understand too late what is happening to us.

Of all the Committees in congress, the Science & Technology Committee has the highest responsibility and the greatest opportunity to correct the short term, erratic course, trade deficit posture into which the nation has floundered. Science & Technology has the mission which, by its nature, must address long term national benefit through a proper posture in Research and Development. I would suggest that this Committee be the nucleus of a new National dedication to a fully competitive posture in international trade through revolutionary products and processes. The proper technology flow for this to happen, from Research and Exploratory Development through Advanced Development, Engineering Development, Product Engineering, and Commercial Introduction, needs to be examined by this Committee, and the proper government or non-government role for each phase must be determined. The drain of technical talent now underway, from the commercial sector into the Defense sector, is clearly not the solution to our balance of trade problems.

Mr. Chairman, the R&D tax credit portion of the Economic Recovery Act is certainly a step in the right direction, but it will, in no way, replace the positive effects of federal R&D funding. Corporate Return on Investment (ROI) criteria remain in place, and the R&D tax credit will help to reduce by about 1/3, the payback time associated with any new R&D expenditure by a profitable company. What this really means is that R&D which would have paid off in 4-5 years, and would, therefore, have been marginal, will now pay off in 3-4 years, falling within the scope of corporate investments. However, and this must be emphasized, the R&D tax credit will do nothing to enhance investment for the 5-10 year time period and beyond. That must remain the province of the federal government if we are to achieve a favorable degree of economic competitiveness. Consistently, again, we are seeing that improvements in energy, productivity,

and trade must be firmly backed by significant involvement of the federal government in research and development in the nondefense sectors of our economy.

The administration has requested a dramatic decrease in government research and development while passing the R&D tax incentive. The thought was to remove government "interference" or "control" on R&D and let the private sector have more say in the matter. "Free Market" has become an often-used expression.

The Japanese are strong proponents of the "free market", but their definition differs substantially from ours. The Japanese concept of the "free market" is the capability for them to trade internationally, in competition with other industralized nations, without having to contend with trade barriers. This international "free market" is addressed with a strong government-industry partnership.

In light of these facts, let us examine the direction our nation has taken in the past year:

In Trade: We have fallen to an all-time low in balance of trade; and it is predicted to get worse. In 1982, it may reach a negative $50 billion. If it were not for the approximately $70 billion due to imports of foreign oil, our trade balance would be positive, although falling.

In Energy: During a temporary oil glut, we are now told the country has no energy crisis. At the same time, foreign oil imports still supply 1/3 of our petroleum needs. Coal research has been drastically cut as have been funds for the transportation systems we desperately need to utilize and export more coal. Funds for conservation in all forms, including radically improved industrial processes, revolutionary energy conversion machinery, advanced engines, new types of appliances, and tightened-up buildings, have been reduced to virtually zero.

In Productivity: We are lagging the rest of the industralized world and we have substantial unemployment, we desparately need industrial revitalization.

In this environment, we are now rapidly refocusing our scientific and engineering talent away from R&D in support of trade, energy, and productivity in the consuming sectors, and are, instead, refocusing our talent onto new, exotic methods of strategic and tactical warfare. In 1980, prior to the implementation of these new policies, R&D in the U.S. had fallen to 2.3% of GNP; of which 1/3 went for defense.

Let us briefly look at what the rest of the world is doing in these areas of trade, energy, and productivity:

In Germany, the level of R&D expenditure has been rising, from 1.6% of GNP in the mid-sixties to 2.4% at present. In Japan, the level is now 2.0% of GNP, with projections indicating 3.0% very soon. Almost all of German and Japanese R&D is directed towards commercial applications.

A salient policy for the 1980's expressed by Japan's MITI is:

> Japan has heretofore borrowed, applied and improved upon imported technologies. In the 1980's, it must switch over to "forward engineering" by increasing budgets for R&D consistant with a "Long-term vision for Technological Development" which identifies priorities, etc. Government R&D has been 1/3 of total R&D; it should be increased to (at least) 1/2.

The Commerce Department states: "More and more of the inventions and improvements that go into technology are occurring abroad. This has ramifications for our foreign policy and for our national security," as well as negative effects on energy, productivity, and trade.

At this point, Mr. Chairman, I would like to turn your attention to a related subject; the economics of trade, productivity, and energy. In the past year, we have seen virtually every economic prediction possible. In this environment, I feel very free to present my own economic analysis.

Figure 1 presents a situation which I have labeled the "Vicious Circle." Every item in the circle effects every other item in the circle. Negative effects are

amplified and passed on, as are positive effects. Briefly, let us trace our way around this circle.

Starting with Industrial Competitiveness, we can see that lower industrial competitiveness with foreign nations automatically leads to balance of trade deficits. Since we can compete less well, we get beaten in the marketplace. Balance of trade deficits mean, simply, that cash flow goes to foreign industry instead of American industry. This means a lower GNP as a result. Lower Gross National Product means less money flow on which taxes are paid, or lower tax revenues. Lower tax revenues, when compared to committed government expenditures, simply lead to larger national budget deficits. Budget deficits, as we all know, lead to government borrowing in the money markets, increasing the demand for capital, resulting in higher interest rates. These interest rates, in turn, lead to lower capability for industry to invest in itself, leading to lower industrial competitiveness. A vicious circle. The question which arises is: At what point on the circle do we attack the problem?

Mr. Chairman, we seem to be the only industralized nation that does not place a minimum balance of trade deficit as our highest national priority. Our attention has been placed on the wrong part of the vicious circle. The budget deficit is more of an effect than a cause. The balance of trade deficit is more of a cause than an effect.

Returning to the results of the Harvard Conference referred to in the opening paragraphs of this statement, the interrelated areas of energy, productivity, and trade must be focused upon in order to increase our industrial competitiveness and "we cannot overemphasize the importance of research and development in achieving this."

The Japanese approach is singularly different from our own in that national benefit plays a major role in selecting areas of Corporate R&D focus. Even corporate investment criteria contain parameters focussed on long term corporate health and national economic health.

In the United States, Government R&D programs in Space, Energy, The Environment, and Defense have nearly always been established to deal with a perceived

national problem and a need for technical and engineering emphasis in a given area. No thought is usually given to profit, or return on investment, but, generally, the measure has been one of national benefit. From the private sector, government sources of funds have generally been sought to address concepts which fall outside normal corporate return-on-investment criteria due to technical risk, or length of time to the market-place. Contrary to popular opinion, it is neither pleasurable nor a privilege to do business with the government. It is a frustrating environment in which to attempt to be successful, but a very necessary function for our nation's longer-term economic competitiveness and security. Our country absolutely needs a function to serve long term national benefit without regard to profit or return-on-investment.

Rather than short term profit only, the Japanese criteria lead to long term programs, successfully aimed at market dominance in multi-billion dollar markets. These markets are further characterized by high employment, high volume of unit sales, and energy efficiency. Examining every recent major push from high mileage automobiles, to videotek, to rapid solid-state computers, to advanced steel-making processes, it is seen that all of these areas of focus fall under the aforementioned criteria.

It is interesting to note that a recent MITI press release announces a new area for focussed attention. The area is Stirling engines from a few kilowatts up to 100 horsepower, for use in residential, commercial, industrial, and transportation applications. The initial increment applied by the Japanese government to this area is $45 million. Normally, this would be more than matched through internal investment by Japanese Corporations. Should the Japanese be successful, the manufacturing- related employment in the United States which would be negatively affected by markets which the equipment would penetrate, is conservatively estimated at 2,000,000 people.

The Energy Conversion Technologies

In the past, industrial firms have routinely testified that new technology would not be developed on a large scale without government support. Why? First, investment will not occur because of the high risk of failure and the long times needed to develop new technology coupled with the very high cost of capital.

Industrial firms usually only look at marginal increases in efficiency and usually to produce better products, not to save energy. Second, many of the energy markets are in areas that have little past experience. The fields of waste heat recovery or the use of new technology in cogeneration do not have a history, therefore, they are hard to sell. Third, the companies which evolve most new energy efficient technology are usually smaller companies with little free capital and have been moving ahead with government support. Fourth, many of the high energy use industries are in financial trouble and will not be able to raise capital for efficiency improvements (automobiles, utilities, and steel). Finally, many products oriented to high energy efficiency are not central to the production process of industrial firms. Therefore, they want assurance that such technologies can work without disturbing normal operations, thus requiring large scale demonstrations in various industrial contexts before a market can be developed.

Government Role

Much of the high technology industry that exists in this country today is a spin off of original government funding for government uses, such as satellite communications as a result of the NASA space program, miniaturization based on NASA and DOD work, and computers based mainly on DOD requirements. I might add that these are also industries where we have led other nations in developments and have been able to apply them to both the domestic and export markets. Since energy efficient processes are not oriented toward government requirements, indirect funding is necessary. At the minimal levels that we have been providing (between $200,000,000 and $300,000,000 per year or one day's oil imports) this funding can be very important to the overall implementation of advanced technologies in industry.

Conservation Conclusions

Programs in industrial conservation have gotten high marks from industrial companies for providing the marginal funds needed to get many technologies underway. In addition, R&D or prototype development is advancing in several areas, such as heat pumps, waste heat recovery systems, more efficient processes in major industries, cogeneration by advanced processes, new turbine technolo-

gies, fuel cell technology, and alternative engines for vehicles and other uses. Without government support, the least risky of these technologies will probably enter the marketplace at some time. The riskier technologies, which are the ones that are normally funded in these programs, probably will not be implemented with domestic technology if government support is not included. These usually also have the highest potential. Because of the high cost of capital and the necessity to concentrate on short range product improvements, many of these technologies will be leapfrogged by foreign competitors using government support, or not implemented at all.

A very strong argument can be made that a large portion of the technology breakthroughs in this country have come about because of government support, not necessarily because of marketplace oriented development. The oil industry, to which we all point as a tremendously profitable enterprise, would not have been able to reach its current status without large government involvement in its earliest stages and throughout most of its history. Even if support is somewhat redundant, a good argument can be made for supporting the R&D being undertaken in the DOE conservation program in order to assure that the energy efficient technologies will get to the market as rapidly as possible. Even if government money should displace private money to some extent, it buys the certainty that those technologies will be developed, rather than a hope that the private sector and the marketplace will do so.

A Final Word

Once an industry or product is established, it seems reasonable to assume that the marketplace should determine its basic profitability and government support should be minimal, except where industry itself is generically supported by government policy. But that argument needs to be tempered in the face of international competitive situations. Other industrial nations are financing high technology components of industry because there is a domestic market as well as a large export market available. The United States on the other hand has been boosting the export of foodstuffs and coal, raw material commodities of the type normally thought to be exported by third world or developing nations. Without government support, we will most likely be importers of synthetic fuels technology and energy efficient technology in the future. It does not seem reasonable

to move ahead with government subsidy of nuclear fuels on one hand without equivalent support to equally important technologies on the other.

We thank you for this opportunity to testify.

Vicious Circle

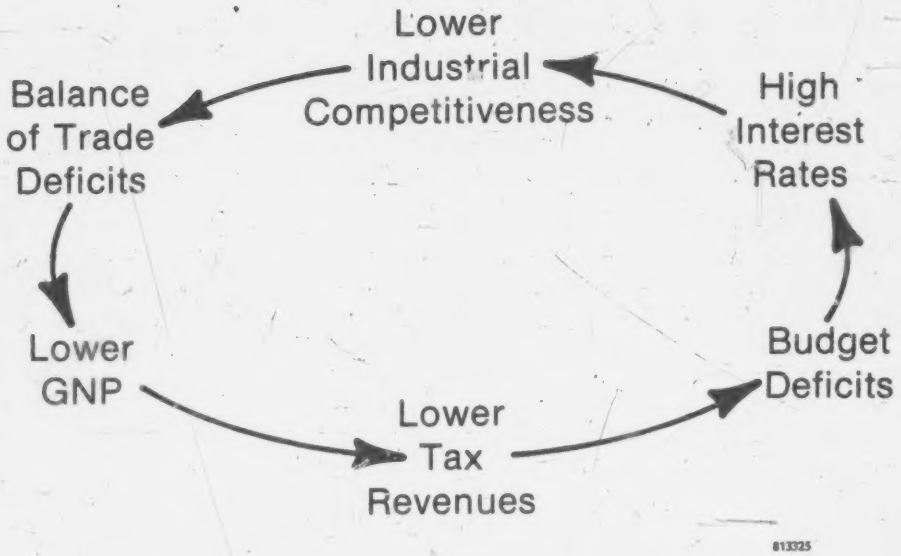

Fig. 1

Mr. FUQUA. Thank you very much.
Dr. Kirsch?

STATEMENT OF WILLIAM KIRSCH, DIRECTOR, CENTER FOR ENERGY MANAGEMENT AND ECONOMICAL DEVELOPMENT, UNIVERSITY CITY SCIENCE CENTER

Dr. KIRSCH. Thank you, Mr. Chairman. I would like to thank you and the members of the subcommittee for this opportunity to discuss the energy analysis and diagnostic center program which has been sponsored by the Department of Energy.

I am William Kirsch, director of the Center for Energy Management and Economic Development in Philadephia, and I have been in charge of the EADC program, as we call it, since it began in 1976.

My immediate purpose is to summarize the progress of this program which under Federal contract has been providing technological assistance and improved profitability in the plants of small- and medium-size manufacturers in seven States, but which could, of course, be bringing its benefits to many more States if additional Federal support were available.

These small- and medium-size manufacturers are a strong component of the Nation's total industrial picture because they are suppliers and purchasers of goods and services from large manufacturers as well as smaller ones. They are, in addition, taxpayers and providers of jobs which are valuable to the economy on a local, State, and regional basis.

Traditionally small- and medium-size manufacturers have been wary of hiring consultants to find energy-efficiency and dollar-saving opportunities in their plants. They are especially skeptical of energy-conserving recommendations that are linked to equipment purchases or computer-controlled energy management systems. At the same time, they do not typically have their own professional staff who are capable of analyzing their energy usage and managing it effectively. They know how to run their businesses, but energy costs go largely unmanaged and become increasingly expensive.

To assist these manufacturers with their energy management problems in a practical manner while furthering the national policy of decreasing petroleum imports, the Federal Government initiated the EADC program in 1976. The original basic concept, which was tested in a pilot program, is the same one in use today. The EADC system is built upon a series of university-based engineering centers, professionally staffed, under centralized management, but with individualized styles of operation that are responsive to the preferences and practices of local manufacturers. These EADC's carry out scheduled site visits to the plants of individual manufacturers; they make measurements and observations and prepare an energy analysis report that offers specific recommendations to conserve energy and dollars in a particular plant. A few months later, a followup inquiry finds out which recommended energy conservation opportunities have been implemented. Some of this implementation generates the purchase of equipment and procurement of services from engineering firms. The EADC program

encourages these private-sector activities but takes no direct part in them.

My staff and I exercise management responsibilities by reviewing each energy analysis report in detail, preparing and codifying the data in a centralized management system. We evaluate field performance by site visits—going with them on energy audits, in other words—and we also visit a sample of manufacturers to determine their degree of satisfaction with the services received.

During the most recent period of this program, these EADC's were located at Georgia Tech, the University of Pittsburgh, the University of Tennessee, the University of Dayton, the University of Kansas, and Oklahoma State University. The first three institutions have been with the program since 1976. The last three began to operate in 1980.

Their considerable achievements can be outlined by the following statistical summary: Overall 339 plants served, employing 67,300 persons; over $11.6 million per year of energy savings identified; more than 3.9 trillion Btu per year of conservation identified; and during 1980–81, measured implementation rates which total 85 percent.

There are three other highlights of the program which I would like to describe briefly. One of these is cost effectiveness. Each year, we calculate the total dollar benefit realized from the EADC program on the basis of measured implementation results. Then we compare them with total program cost. The method used to calculate the rate of return is often called the discounted cash flow method. It is also known as interest rate of return or internal rate of return.

The Federal Government's investment is represented by the total contract dollars. For the private sector, we include development costs and implementation costs which are the total installed capital costs of all implemented energy conservation opportunities determined individually for each one. We do not count benefits until 1 year after implementation.

The net cash flow is, of course, the difference between savings and cost, and this difference produces incremental earnings for the participating manufacturers, but these incremental earnings also increase their tax base.

These changes in the tax base, in our analysis, were assumed to be taxable at a 50-percent rate so that manufacturers' net gain was in fact only half the total savings, and the other half became incremental tax income to the Federal Government.

Calculating rate of return for the EADC program by using the data from the implementation study, we find that the client firms expect to realize a 408-percent annual rate of return after taxes from the 1980–81 phase of the program. The tax revenues resulting from the firms' incremental earnings will represent almost 106 percent annual rate of return to the Government as a result of its single 1980–81 investment in the program.

The Federal Government's contractual support thus becomes a kind of seed investment which not only benefits the private sector, but also generates a full return to the Government.

The second highlight I would like to describe is the educational effect of the EADC's. During 1980–81, a total of 32 students worked

on the program, and at least 6 of them went on to industrial jobs for which they successfully competed on the basis of their EADC experience. The EADC's also conduct annual, 1-day conferences for their industrial clients, and at these conferences manufacturers share energy-related experience, and they learn new technological developments, especially those sponsored by DOE, from the EALC staff.

The third highlight is not easily summarized, but it offers a first-hand picture of what small- and medium-size manufacturers think of the program. We assemble this picture by interviewing a sample of the clients in their plants and offices in person. As a result, we know they realize that the program is federally funded; they like the individual approach and the practical, specific recommendations it offers. As the primary and secondary benefits, they most often cite the revelations and confirmed suspicions about energy waste and the ways it offers to lower operating costs. In addition, they corroborate our judgments about thoroughness, competence, and dedication of the EADC staff who served them.

Near the conclusion of each interview, we ask these manufacturers if they think that the EADC program represents a good expenditure of taxpayers' dollars. Each of them pauses to think that one over before he answers. For the 1980–81 program, 20 out of 23 said yes to this question. Two others were uncertain, and one other said that he liked the report he received, but all he wanted the Government to do was fix the roads and keep out the Russians, but he liked his report.

I think that 20 out or 23 represent a very high degree of taxpayer approval.

In summary, I have been describing this federally supported program that delivers needed management services to a sector of the economy that is unable to provide them for itself. We have established, we think, a consistent record for implementation, and we think that the program has created a strong satisfaction among the taxpayers on the basis of the expenditure of their dollars.

What the program needs most is a continuing Federal investment first to enable us to go on serving the small- and medium-sized manufacturers of these seven States; and, second, to bring its benefits to the industries of many more States.

It is with a certain amount of pardonable pride that I point to this program as a proven example of an effective Federal stimulus to the private sector.

My full statement and supporting information have been provided to the subcommittee, and I ask that they be considered as part of the record.

[The prepared statement of Dr. Kirsch follows:]

STATEMENT

OF

DR. F. WILLIAM KIRSCH
UNIVERSITY CITY SCIENCE CENTER

FOR

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
ROOM 2318, RAYBURN BUILDING

MARCH 11, 1982

STATEMENT OF DR. F. WILLIAM KIRSCH

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE, I THANK YOU FOR THIS OPPORTUNITY TO DISCUSS THE ENERGY ANALYSIS AND DIAGNOSTIC CENTER PROGRAM SPONSORED BY THE DEPARTMENT OF ENERGY. I AM WILLIAM KIRSCH, DIRECTOR OF THE CENTER FOR ENERGY MANAGEMENT AND ECONOMIC DEVELOPMENT, AND I HAVE BEEN IN CHARGE OF THE EADC PROGRAM SINCE IT BEGAN IN 1976.

MY IMMEDIATE PURPOSE IS TO SUMMARIZE THE PROGRESS OF THIS PROGRAM, WHICH UNDER FEDERAL CONTRACT HAS BEEN PROVIDIING TECHNOLOGICAL ASSISTANCE AND IMPROVED PROFITABILITY IN THE PLANTS OF SMALL AND MEDIUM-SIZE MANUFACTURERS OF 7 STATES BUT WHICH COULD BE BRINGING ITS BENEFITS TO MANY MORE STATES IF ADDITIONAL FEDERAL SUPPORT WERE AVAILABLE. THESE MANUFACTURERS ARE A STRONG COMPONENT OF THE NATION'S TOTAL INDUSTRIAL PICTURE, BECAUSE THEY ARE SUPPLIERS AND PURCHASERS OF GOODS AND SERVICES FROM LARGE MANUFACTURERS AS WELL AS SMALLER ONES. THEY ARE, IN ADDITION, TAXPAYERS AND PROVIDERS OF JOBS WHO ARE VALUABLE TO THE ECONOMY ON A LOCAL, STATE, AND REGIONAL BASIS.

TRADITIONALLY, SMALL AND MEDIUM-SIZE MANUFACTURERS HAVE BEEN WARY OF HIRING CONSULTANTS TO FIND ENERGY EFFICIENCY AND DOLLAR SAVING OPPORTUNITIES IN THEIR PLANTS. THEY ARE ESPECIALLY SKEPTICAL OF ENERGY CONSERVING RECOMMENDATIONS THAT ARE LINKED TO EQUIPMENT PURCHASES OR COMPUTER CONTROLLED ENERGY MANAGEMENT SYSTEMS. AT THE SAME TIME, THEY DO NOT TYPICALLY HAVE THEIR OWN PROFESSIONAL STAFF WHO ARE CAPABLE OF ANALYZING THEIR ENERGY USAGE AND MANAGING IT EFFECTIVELY. THEY KNOW HOW TO RUN THEIR BUSINESSES, BUT ENERGY COSTS GO LARGELY UNMANAGED AND BECOME INCREASINGLY EXPENSIVE.

TO ASSIST THESE MANUFACTURERS WITH THEIR ENERGY MANAGEMENT PROBLEMS IN A PRACTICAL MANNER WHILE FURTHERING A NATIONAL POLICY OF DECREASING PETROLEUM IMPORTS, THE FEDERAL GOVERNMENT INITIATED THE ENERGY ANALYSIS AND DIAGNOSTIC CENTER PROGRAM IN 1976. THE ORIGINAL BASIC CONCEPT, WHICH WAS TESTED IN A PILOT PROGRAM, IS THE SAME ONE IN USE TODAY. THE EADC SYSTEM IS BUILT UPON A SERIES OF UNIVERSITY BASED ENGINEERING CENTERS, PROFESSIONALLY STAFFED, UNDER CENTRALIZED MANAGEMENT BUT WITH INDIVIDUALIZED STYLES OF OPERATION THAT ARE RESPONSIVE TO THE PREFERENCES AND PRACTICES OF LOCAL MANUFACTURERS. THESE EADCs CARRY OUT SCHEDULED SITE VISITS TO THE PLANTS OF INDIVIDUAL MANUFACTURERS, MAKE MEASUREMENTS AND OBSERVATIONS, AND PREPARE AN ENERGY ANALYSIS REPORT THAT OFFERS SPECIFIC RECOMMENDATIONS TO CONSERVE ENERGY AND DOLLARS IN A PARTICULAR PLANT. A FEW MONTHS LATER, A FOLLOW-UP INQUIRY FINDS OUT WHICH RECOMMENDED ENERGY CONSERVATION OPPORTUNITIES (ECOs) HAVE BEEN IMPLEMENTED. SOME OF THIS IMPLEMENTATION GENERATES THE PURCHASE OF EQUIPMENT AND THE PROCUREMENT OF SERVICES FROM ENGINEERING FIRMS. THE EADC PROGRAM ENCOURAGES THESE PRIVATE SECTOR ACTIVITIES BUT TAKES NO DIRECT PART IN THEM.

IN EXERCISING OUR MANAGEMENT RESPONSIBILITIES FOR THE ENTIRE PROGRAM, MY STAFF AND I REVIEW EACH ENERGY ANALYSIS REPORT IN DETAIL AND PREPARE A WRITTEN CRITIQUE WHICH GOES TO THE EADC. WE ALSO CODIFY THE DATA AND ENTER THEM INTO OUR CENTRALIZED DATA MANAGEMENT SYSTEM, EVALUATE EACH EADC'S PERFORMANCE IN THE FIELD AT PERIODIC INTERVALS, AND THEN VISIT A SAMPLE OF REPRESENTATIVE INDUSTRIAL CLIENTS TO ASCERTAIN THEIR SATISFACTION WITH THE SERVICES RECEIVED. WE ARE VERY ACTIVE MANAGERS.

DURING THE MOST RECENT PERIOD OF THE PROGRAM, EADCs WERE LOCATED AT GEORGIA TECH, THE UNIVERSITY OF PITTSBURGH, THE UNIVERSITY OF TENNESSEE, THE UNIVERSITY OF DAYTON, THE UNIVERSITY OF KANSAS, AND OKLAHOMA STATE UNIVERSITY. THE FIRST THREE INSTITUTIONS HAVE BEEN WITH THE PROGRAM SINCE 1976; THE LAST THREE BEGAN TO OPERATE IN 1980.

THEIR CONSIDERABLE ACHIEVEMENTS CAN BE OUTLINED BY THE FOLLOWING STATISTICAL SUMMARY:

- 339 PLANTS SERVED, EMPLOYING 67,300 PERSONS.
- OVER $11.6 MILLION/YEAR SAVINGS IDENTIFIED.
- MORE THAN 3.9 TRILLION BTU/YEAR CONSERVATION IDENTIFIED.
- MEASURED 1980-81 IMPLEMENTATION RATES:
  54% DURING 1980-82, PLUS 31% SCHEDULED FOR 1983.

THERE ARE THREE OTHER HIGHLIGHTS OF THE EADC PROGRAM WHICH I WOULD LIKE TO DESCRIBE BRIEFLY. ONE OF THESE HIGHLIGHTS IS COST-EFFECTIVENESS. EACH YEAR, WE CALCULATE THE TOTAL DOLLAR BENEFITS REALIZED FROM THE EADC PROGRAM ON THE BASIS OF MEASURED IMPLEMENTATION RESULTS, AND THEN WE COMPARE THEM WITH THE TOTAL PROGRAM COST. THE METHOD USED TO CALCULATE THE RATE OF RETURN IS OFTEN CALLED THE DISCOUNTED CASH FLOW METHOD BUT IS ALSO KNOWN AS THE INTEREST-RATE-OF-RETURN OR THE INTERNAL RATE OF RETURN METHOD. THE FEDERAL GOVERNMENT'S INVESTMENT IS REPRESENTED BY THE TOTAL CONTRACT DOLLARS. FOR THE PRIVATE SECTOR, WE INCLUDE DEVELOPMENT COSTS AND IMPLEMENTATION COSTS, WHICH ARE THE TOTAL INSTALLED CAPITAL COSTS OF ALL IMPLEMENTED ENERGY CONSERVATION OPPORTUNITIES (DETERMINED SEPARATELY FOR EACH ECO). WE DO NOT COUNT BENEFITS UNTIL ONE YEAR AFTER IMPLEMENTATION.

NET CASH FLOW IN A GIVEN YEAR IS THE DIFFERENCE BETWEEN SAVINGS AND COST, AND THIS DIFFERENCE PRODUCES INCREMENTAL EARNINGS FOR THE PARTICIPATING MANUFACTURERS THAT ALSO INCREASE THEIR TAX BASE.

THESE CHANGES IN THE TAX BASE WERE ASSUMED TO BE TAXABLE AT A 50% RATE, SO THAT THE MANUFACTURERS' NET GAIN WAS IN FACT ONLY HALF THE TOTAL SAVINGS. THE OTHER HALF BECAME INCREMENTAL TAX INCOME TO THE FEDERAL GOVERNMENT IN OUR ANALYSIS.

CALCULATING RATE OF RETURN FOR THE EADC PROGRAM BY USING THE DATA FROM THE IMPLEMENTATION STUDY, WE FIND THAT THE CLIENT FIRMS EXPECT TO REALIZE A 408% ANNUAL RATE OF RETURN AFTER TAXES FROM THE 1980-81 PHASE OF THE PROGRAM. THE TAX REVENUES RESULTING FROM THE FIRMS' INCREMENTAL EARNINGS WILL REPRESENT A 105.9% ANNUAL RATE OF RETURN TO THE GOVERNMENT AS A RESULT OF ITS SINGLE 1980-81 INVESTMENT IN SUPPORT OF THE PROGRAM. THE FEDERAL GOVERNMENT'S CONTRACTUAL SUPPORT THUS BECOMES A SEED INVESTMENT WHICH NOT ONLY BENEFITS THE PRIVATE SECTOR BUT ALSO GENERATES A FULL RETURN TO THE GOVERNMENT.

THE SECOND HIGHLIGHT I WOULD LIKE TO DESCRIBE IS THE EDUCATIONAL EFFECT OF EADCs. DURING 1980-81, A TOTAL OF 32 STUDENTS WORKED ON THE PROGRAM, AND AT LEAST 6 OF THEM WENT ON TO INDUSTRIAL JOBS FOR WHICH THEY SUCCESSFULLY COMPETED ON THE BASIS OF THEIR EADC EXPERIENCE. THE EADCs ALSO CONDUCT ANNUAL ONE-DAY CONFERENCES FOR THEIR INDUSTRIAL CLIENTS. AT THESE CONFERENCES, MANUFACTURERS SHARE ENERGY-RELATED EXPERIENCES AND LEARN NEW TECHNOLOGICAL DEVELOPMENTS FROM THE EADC STAFF.

THE THIRD HIGHLIGHT IS NOT EASILY SUMMARIZED, BUT IT OFFERS A FIRST-HAND PICTURE OF WHAT SMALL AND MEDIUM-SIZE MANUFACTURERS THINK OF THE EADC PROGRAM. WE ASSEMBLE THIS PICTURE BY INTERVIEWING A SAMPLE

OF EADC CLIENTS IN THEIR PLANTS AND OFFICES. AS A RESULT, WE KNOW THEY REALIZE THE PROGRAM IS FEDERALLY FUNDED; THEY LIKE THE INDIVIDUAL APPROACH AND THE PRACTICAL, SPECIFIC RECOMMENDATIONS IT OFFERS; AND AS THE PRIMARY AND SECONDARY BENEFITS, THEY MOST OFTEN CITE THE REVELATIONS AND CONFIRMED SUSPICIONS ABOUT ENERGY WASTE AND THE WAYS IT OFFERS TO LOWER OPERATING COSTS. IN ADDITION THEY CORROBORATE OUR JUDGMENTS ABOUT THE THOROUGHNESS, COMPETENCE, AND DEDICATION OF THE EADC STAFF WHO SERVED THEM.

NEAR THE CONCLUSION OF EACH INTERVIEW, WE ASK THESE MANUFACTURERS IF THEY THINK THE EADC REPRESENTS A GOOD EXPENDITURE OF TAXPAYERS' DOLLARS. EACH OF THEM PAUSES TO THINK THAT ONE OVER BEFORE HE ANSWERS. FOR THE 1980-1982 PROGRAM, 20 OUT OF 23 SAID YES TO THIS QUESTION. TWO OTHERS WERE UNCERTAIN, AND ONE OTHER SAID HE LIKED THE REPORT HE RECEIVED BUT ALL HE WANTED THE GOVERNMENT TO DO IS "FIX THE ROADS AND KEEP OUT THE RUSSIANS." I THINK THAT 20 OUT OF 23 REPRESENT A VERY HIGH DEGREE OF TAXPAYER APPROVAL.

IN SUMMARY, I HAVE BEEN DESCRIBING A FEDERALLY SUPPORTED PROGRAM THAT DELIVERS NEEDED ENERGY MANAGEMENT SERVICES TO SMALL AND MEDIUM-SIZE MANUFACTURERS WHO LACK THE STAFF RESOURCES TO ENHANCE THEIR ENERGY EFFICIENCY AND THEIR PROFITABILITY. THIS EADC PROGRAM HAS ESTABLISHED A CONSISTENT RECORD FOR IMPLEMENTATION OF ITS RECOMMENDATIONS AND A REPUTATION FOR HIGH RATES OF RETURN TO THE PRIVATE SECTOR AND THE FEDERAL GOVERNMENT. MOREOVER, THE PROGRAM HAS CREATED A STRONG SATISFACTION AMONG TAXPAYERS, WHO SAY IT REPRESENTS A GOOD EXPENDITURE OF THEIR TAX DOLLARS.

WHAT THE EADC PROGRAM NEEDS MOST IS A CONTINUING FEDERAL INVESTMENT - FIRST, TO ENABLE IT TO GO ON SERVING THE SMALL AND MEDIUM-SIZE MANUFACTURERS OF 7 STATES; SECOND, TO BRING ITS BENEFITS TO THE INDUSTRY OF MANY MORE STATES. IT IS WITH PARDONABLE PRIDE THAT I POINT TO THE EADC PROGRAM AS A PROVEN EXAMPLE OF AN EFFECTIVE FEDERAL STIMULUS TO THE PRIVATE SECTOR.

MY FULL STATEMENT AND SUPPORTING INFORMATION HAVE BEEN PROVIDED TO THE SUBCOMMITTEE, AND I ASK THAT THEY BE CONSIDERED AS PART OF THE RECORD. THANK YOU.

DR. F. WILLIAM KIRSCH, DIRECTOR
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DR. F. WILLIAM KIRSCH

Biographical Information

Dr. F. William Kirsch is the Director of the Center for Energy Management and Economic Development, which is the department of University City Science Center that is responsible for designing, evaluating, and carrying out projects and programs in these fields.

At University City Science Center he has directed and carried out a variety of projects in manufacturing efficiency improvement and natural gas supply and demand and cogeneration of heat and power, including regulatory analyses, price and supply forecasting, policy development and analysis, and assessments of technological and economic infrastructure requirements and impacts of energy supply dislocations. These projects have been carried out under contract to federal, state, and local government as well as to private sector corporations and international financial institutions in this nation and abroad.

Prior to joining University City Science Center, Dr. Kirsch had extensive experience in research, development, and manufacturing in petroleum, chemical, and food processing industries.

ENERGY ANALYSIS AND DIAGNOSTIC CENTERS

A Program of Direct Energy Conservation Assistance for Small and Medium-size Manufacturers

BACKGROUND

The Energy Analysis and Diagnostic Center (EADC) program has been providing energy management assistance to small and medium-size manufacturers since 1976. Sponsored by the Department of Energy and managed by the University City Science Center through its Center for Energy Management and Economic Development (CEMED), this program had provided technological assistance and economic evaluations in the plants of 359 manufacturers in 7 states by July, 1981.

Under the EADC program, energy analyses are carried out in the plants of small and medium-size manufacturers by engineers from the faculty and professional staff of 6 major universities. As part of their managerial responsibility, CEMED staff review in detail and prepare a critique of each energy analysis report, provide a centralized data management system, evaluate EADC performance in the field, and periodically visit industrial clients to ascertain their satisfaction with the services received.

Three of the universities--Georgia Tech, the University of Pittsburgh, and the University of Tennessee--have participated since the program began. In October, 1980, the program was expanded to include the University of Dayton, the University of Kansas, and Oklahoma State University.

The overall goal of the program is to conserve energy in an important but often overlooked segment of industry by demonstrating how energy management can be profitable for individual firms while lessening the nation's dependence upon petroleum imports. Unlike their larger counterparts, small and medium-size firms often do not have professional staff who are capable

of designing and carrying out their own energy conservation plans.

To achieve this goal, each EADC contacts manufacturers within a 100-mile radius and offers, free of charge, to visit the plant, analyze process operations and energy use, and provide both energy management information and technical assistance in improved efficiency of energy utilization. The overall effect is not only an improvement in energy use and a reduction in costs, but also higher productivity in the plant and a stronger climate for economic development in the region.

ACHIEVEMENTS

Substantial achievements have been registered by the EADCs in serving the needs of small and medium-size manufacturers in these states. By the end of 1981, they identified over 3900 billion BTUs per year of energy conservation opportunities (ECOs) with an annual value of over $11.6 million in current dollars. These totals represent 12.7% of the BTUs consumed by the manufacturers served and 10.3% of their purchase price. The very different prices for specific energy sources (e.g., electricity and natural gas) account for the difference in percentages between BTUs and dollars.

One of the distinguishing features of the EADC program is a formalized and continuing effort to measure implementation of recommended ECOs. This effort indicates an overall ECO implementation rate of about 85% within approximately two years following the energy analysis in the plant for the 1980-81 phase of the program.

During that time, the six EADCs found that about 290 billion BTUs and over $1.3 million per year of energy conservation opportunities identified had either been implemented or would be not later than 1983. These quantities represent 85% of the potential BTU conservation identified and 85% of the total dollars spent for these BTUs in 1980 by the manufacturers

served by this program. Approximately 57% out of the 85% implemented energy conservation is directly related to manufacturing operations; the other 28% was used for providing building services such as heat and light. Natural gas accounted for most of the implemented energy conservation with 53%, followed in turn by electricity, fuel oil, and coal.

Each year, the total dollar benefits realized from the EADC program are calculated from the implementation results and compared with the total program cost. From each year's measured implementation rate and the total costs - including federal dollars and private sector capital and personnel costs - a series of year-by-year net cash flows are prepared. These are then subjected to a standard financial analysis. The results of this analysis for 1980-81 show an estimated 408% rate of return (after taxes) to the participating manufacturers on their overall capital investment and other implementation costs. Moreover, the increased tax revenues resulting from manufacturers' incremental earnings (decreased energy costs) offer the federal government a 106% rate of return on the contractual support which the Department of Energy provided for that phase of the program. The details of this analysis have been presented in the Science Center's report, "Energy Analysis and Diagnostic Centers, 1980-81."

ORGANIZATION AND OPERATIONS

The present EADC program is being carried out by five Energy Analysis and Diagnostic Centers, managed by the Science Center in Philadelphia but based individually at the following institutions of higher learning:

- Georgia Institute of Technology, Atlanta, GA
- University of Tennessee at Knoxville, TN
- University of Kansas, Lawrence, KS
- Oklahoma State University, Stillwater, OK
- University of Dayton, Dayton, OH

They are expected to serve the energy conservation needs of an additional 360 manufacturers by February, 1983.

There are some clear advantages to having EADCs centered locally. Owners and managers of small and medium-size companies are more likely to react favorably to professionals who are not only technically proficient, but who are also familiar with the structure of industry in their own locale, the lifestyles and operating approaches of managers and employes, and any special problems unique to the area. Local professionals are also more familiar with local characteristics such as weather, fuel availability, and personnel attitudes.

Also, because the EADC program is a prominent and easily identifiable entity on a nearby--and locally respected--university campus, the client firms have easy access to professional personnel to ask questions, to discuss the progress of implementation, and to request further technical assistance when it is appropriate.

There are also advantages for the EADC, the federal government, and the clients served by this program in centralizing EADC management in a single firm under contract to the sponsoring agency or department. University City Science Center's staff who have managed this program combine advanced technological knowledge with many years' industrial experience. They periodically evaluate the program by a series of effectiveness evaluation visits to the EADCs and by field interviews with a sample of firms served. Though it is important to preserve some individuality in the operations of the EADCs--especially in regard to local differences in approach to industrial energy conservation--a degree of consistency obtained by central management is also desirable to assure the quality of information provided, to maintain a high level of performance, and to permit easy comparison among the program's quantifiable achievements.

The Science Center receives copies of all client reports and prepares a formal critique of each for the EADC, though the clients' names are held in confidence at the EADC location. With these reports, the Science

Center's staff reviews, summarizes, and computerizes data on actual energy use in various industries and on measured energy conservation achieved at these particular firms through the aid of the EADC program. The result is a computerized master file (without names of firms) containing over 1400 ECOs that can be tabulated by category of energy use, SIC code, and EADC and that can also be cross-tabulated according to the type of opportunity recommended. For example, these data show that by September 1981, over half the ECOs identified were in the services category, which represents energy used to supply heat or power in an auxiliary manner to a process or a product. They also reveal that the three industries in which the largest total savings were identified in 1980-81 were textile mill products, food processing, and apparrel and similar products.

METHODOLOGY

An individual Energy Analysis and Diagnostic Center serves the energy-related needs of its clients through an anlysis of each plant's operating characteristics and energy requirements. That is its specific mission. This analysis occurs through a site visit to the client's plant by the EADC director or his substitute--an engineering professional connected to the college--and the necessary staff, which includes graduate students and advanced undergraduates. Prior to the visit, the professional reviews descriptive information on the plant, including copies of its utility bills and other fuel purchase records.

The site visit begins with a meeting with the plant manager and his operating staff to discuss the plant's operations and energy usage as well as to review the preliminary analysis made by the EADC director from the information received in advance. Accompanied by the plant representatives, the energy audit team then proceeds to:

- Measure the combustion efficiency for all major fuel burning equipment in the plant.

- Measure the operating parameters of relatively large electric motors and electrically energized equipment.
- Make other relevant measurements of factors affecting production-related energy consumption and lossess, such as wall temperatures of kilns and process vessels, process fluid flows, and steam use characteristics.
- Inspect and measure energy consumption characteristics of buildings, including ventilation levels, insulation and wall openings, and lighting intensities.

After each site visit, the audit team identifies and evaluates at least three energy conservation opportunities, considering possible changes in plant operating schedules and procedures as well as equipment modifications and replacements. A brief report of all findings and recommendations is prepared and presented to the manufacturer, with an anonymous copy sent to the Science Center for evaluation. An analysis of probable costs and the dollar savings that can be realized are included in each report. However, the EADC does not carry out engineering designs, offer performance guarantees on equipment or processes, or recommend particular equipment vendors or manufacturers. When energy conservation measures requires that kind of service or information, the option belongs to the plant management to seek professional assistance elsewhere as needed.

The EADC program has demonstrated that expert local capabilities can effectively address the energy needs of local manufacturers when guided by a participating centralized management. The end result is a practical service delivery system offering an attractive return on the federal government's supporting dollars.

Additional information and detailed reports on the EADC program are available from:

Dr. F. William Kirsch, Director
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University City Science Center
3624 Market Street
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215-387-2255

95-882 O—82——9

ENERGY ANALYSIS AND DIAGNOSTIC CENTERS 1980-81

A PROGRAM OF DIRECT ENERGY CONSERVATION ASSISTANCE FOR MEDIUM-SIZE AND SMALL MANUFACTURERS

EXCERPTS

This report was prepared for the Department of Energy under Contract No. DE-AC-01-78CS-40091

by

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AUGUST, 1981

University City Science Center

Implemented Energy Conservation Opportunities

The Energy Analysis and Diagnostic Center (EADC) program sponsored by the Department of Energy provided energy conservation services in the plants of 171 small and medium-size manufacturers during 1980-81, the most recent phase of the program. Since the program was designed and begun in 1976 by the staff of the University City Science Center, more than 360 manufacturers have benefited from it. This report presents comprehensive results based upon 151 individual energy analyses carried out during 1980-81; the other 20 will be reported as soon as the complete results become available.

These 151 plants employ about 28,200 persons, generate a total of $3.1 billion per year in gross sales, and encompass 19 industries (2-digit SIC codes). They were served by EADCs located at colleges of engineering in 6 states. Three of them - Georgia Tech, the University of Pittsburgh, and the University of Tennessee (Knoxville) - have been providing these energy services from the program's beginning. The Department of Energy created 3 new EADCs during 1980-81, by means of a competitive solicitation, at the University of Dayton, the University of Kansas, and Oklahoma State University.

From its beginning, the EADC program has had four major characteristics:

- On-site energy analyses and specific energy conservation opportunities (ECOs) recommended for individual plants.
- Technical and managerial assistance provided to all EADCs by the Science Center's staff.
- Periodic evaluation visits to industrial clients by the Science Center's staff.
- Measured implementation of ECOs recommended to each manufacturer.

Implementation is, however, the ultimate measure of the program's effectiveness, and for that reason it will be reported in this first chapter. In later chapters, we will describe and analyze the full range of energy conservation identified according to the individual energy source being consumed, the category of its use, and the industry in which it was found. An evaluation report based upon personal interviews with client manufacturers has already been issued ("Energy Management Assistance for Small and Medium-size Manufacturers: An Evaluation of the EADC Programs," by F. W. Kirsch, UCSC, April, 1981).

During 1980-81, recommended energy conservation measures have been implemented to the degree that 54.4% of the BTU conservation and 50.6% of the dollar savings have been implemented or are in progress, and an additional 30.5% of BTU conservation and 35.4% of dollar savings are expected to be implemented by the end of 1983 (Tables 1 and 2). These results are based upon follow-up studies by the 6 EADCs that were able to elicit responses from 101 of the 151 manufacturers who had been served by the EADC program. Some energy analyses were carried out so recently that the manufacturers have not yet been able to decide upon implementation, but we believe that the 101 who responded are a representative sample of the total population of 151.

In collecting and tabulating 1980-81 implementation results, we utilized the same categories developed for the 1979 study. According to this system, responses are grouped into 1 of 3 broad categories: 1) implemented, 2) being considered, or 3) not to be implemented. In the first category we placed all energy conservation opportunities (ECOs) that have been completed, that are in progress, and that are planned for implementation during 1982. The second category includes those expected to be implemented not later than 1983. All other responses were considered as ECOs not to be implemented.

TABLE 1

IMPLEMENTATION OF ENERGY CONSERVATION OPPORTUNITIES

JULY, 1981

ENERGY SOURCE	ANNUAL CONSERVATION MMBTU	%	ANNUAL SAVINGS DOLLARS	%	COST OF IMPLEMENTATION DOLLARS
ELECTRICITY					
IMPLEMENTED	1852.	5.4	250014.	16.3	258652.
BEING CONSIDERED	5776.	1.7	87598.	5.7	154757.
NOT TO BE IMPLEMENTED	8819.	2.6	82703.	5.4	
TOTAL	33177.	9.7	420315.	27.4	
NATURAL GAS					
IMPLEMENTED	162957.	47.7	459530.	30.0	557502.
BEING CONSIDERED	80611.	23.6	237623.	15.5	451099.
NOT TO BE IMPLEMENTED	39768.	11.6	116224.	7.6	
TOTAL	283336.	82.9	813377.	53.1	
FUEL OIL					
IMPLEMENTED	4229.	1.2	65800.	4.3	30190.
BEING CONSIDERED	-6752.	-2.0	168959.	11.0	65697.
NOT TO BE IMPLEMENTED	1779.	0.5	9878.	0.6	
TOTAL	-744.	-0.2	244637.	16.0	
COAL					
IMPLEMENTED	0.	0.0	0.	0.0	0.
BEING CONSIDERED	23450.	6.9	42000.	2.7	175000.
NOT TO BE IMPLEMENTED	0.	0.0	0.	0.0	
TOTAL	23450.	6.9	42000.	2.7	
OTHER					
IMPLEMENTED	0.	0.0	0.	0.0	0.
BEING CONSIDERED	1164.	0.3	6650.	0.4	12500.
NOT TO BE IMPLEMENTED	1358.	0.4	5557.	0.4	
TOTAL	2522.	0.7	12007.	0.8	
ALL ENERGY SOURCES					
IMPLEMENTED	185768.	54.4	775344.	50.6	846344.
BEING CONSIDERED	104249.	30.5	542630.	35.4	859053.
NOT TO BE IMPLEMENTED	51724.	15.1	214362.	14.0	
TOTAL	341741.	100.0	1532336.	100.0	

TABLE 2

IMPLEMENTATION OF ENERGY CONSERVATION OPPORTUNITIES

JULY, 1981

ENERGY CATEGORY	ANNUAL CONSERVATION MMBTU	%	ANNUAL SAVINGS DOLLARS	%	COST OF IMPLEMENTATION DOLLARS
PRODUCTION					
IMPLEMENTED	27781.	8.1	86315.	5.6	197631.
BEING CONSIDERED	13148.	3.8	42608.	2.8	59084.
NOT TO BE IMPLEMENTED	10568.	3.1	35931.	2.3	
TOTAL	51497.	15.1	164854.	10.8	
SERVICES					
IMPLEMENTED	93170.	27.3	369000.	24.1	235663.
BEING CONSIDERED	51425.	15.0	367046.	24.0	432884.
NOT TO BE IMPLEMENTED	18399.	5.4	92186.	6.0	
TOTAL	162994.	47.7	828232.	54.1	
HVAC					
IMPLEMENTED	30907.	9.0	102662.	6.7	263801.
BEING CONSIDERED	36227.	10.6	96253.	6.3	317592.
NOT TO BE IMPLEMENTED	20871.	6.1	74989.	4.9	
TOTAL	88005.	25.8	273904.	17.9	
HOUSEKEEPING					
IMPLEMENTED	33910.	9.9	217367.	14.2	149249.
BEING CONSIDERED	3449.	1.0	36723.	2.4	48593.
NOT TO BE IMPLEMENTED	1886.	0.6	11255.	0.7	
TOTAL	39245.	11.5	265346.	17.3	
ALL ENERGY CATEGORIES					
IMPLEMENTED	185768.	54.4	775344.	50.6	846344.
BEING CONSIDERED	104249.	30.5	542630.	35.4	859053.
NOT TO BE IMPLEMENTED	51724.	15.1	214362.	14.0	
TOTAL	341741.	100.0	1532336.	100.0	

Natural gas is the energy source which is responsible for most of the implementation (61.6% out of 84.9% total implementation on a BTU basis; 45.5% out of 86.0% total implementation on a dollar basis). Among the 4 categories of energy use, services - defined as energy used to supply heat or power to a process or product in an auxiliary manner - is responsible for most of the implementation (42.3% out of 84.9% total on a BTU basis; 48.1% out of 86.0% total on a dollar basis).

However, natural gas and the services category also account for the largest amounts of identified BTU conservation and dollar savings. We think it is equally informative and useful to examine these results by expressing the implemented dollar savings as a percentage of the dollar savings identified. When we do that and include simple payback times and average energy prices, we get the following results:

Energy Source	Average Payback (yr.)	Average* Energy Price ($/10^6 BTU)	Implemented $ Savings Identified $ Savings (Percent)
Electricity	1.22	9.14	80.3
Natural Gas	1.45	2.80	85.7
Fuel Oil	0.41	5.31	96.0
Coal	4.17	1.73	100.0
Other	1.94	4.75	53.7
Category of Use**			
Housekeeping	0.78	6.76	95.8
Services	0.91	5.08	88.9
Production	2.00	3.20	78.2
HVAC	2.92	3.11	72.6

* Based upon consumption data for these 101 plants.

**Defined in Appendix I of this report.

On this basis, we find no simple correlation between implementation and payback time or average energy price of the energy sources. However, there is an apparent correlation of implementation with payback time and average energy price for the 4 categories of energy use. Those categories with the shortest payback times and highest average price show the highest degree of implementation compared to the dollar savings. Although this apparent correlation among categories of use agrees with classical economic concepts, we are not suggesting that the apparent correlations have been firmly established by these data.

Similarily, if we examine implementation on the basis of implemented conservation as a percentage of consumption for each energy source, there is no apparent correlation with either payback time or the average energy price. The following data represent a summary:

Energy Source	Implemented/Being Considered Energy Conserv. Dollar Saving (as % consumption)		Average Payback (yrs.)	Average Energy Price $/10^6 BTU)
Electricity	0.87	1.32	1.22	9.14
Natural Gas	6.66	6.80	1.45	2.80
Fuel Oil	--	37.94	0.41	5.31
Coal	3.93	4.07	4.17	1.73
Other	16.35	35.51	1.94	4.75

As we have pointed out previously, a manufacturer's decision to implement energy conservation must take into account a broad spectrum of factors like the state of the total economy and earnings patterns, the availability of capital (and the size of interest rates), the reliability of supply and future prices of various energy sources, and the required rate of return on investment. Especially for small and medium-size manufacturers the decision to implement often depends most strongly on its effects upon production and cash flow. Energy conservation measures most likely to be implemented are

those which do not lessen a plant's productive capacity or interrupt production for a long time and the cost of which is compatible with cash flow requirements.

In summary, these 1980-81 results not only show high rates of implementation but also indicate a dramatic increase over the 55.3% BTU implementation rate and the 57.5% dollar implementation rate observed during the preceding (1979) phase of the EADC program (Energy Analysis and Diagnostic Centers: A Financial Analysis of Return on Investment in the EADC Program" by F. H. McIlvain, Jr., and F. W. Kirsch, UCSC, January, 1981).

Public and Private Returns on Investment in Energy Conservation

As discussed in the previous chapter, one of the primary features of the EADC program is the direct assessment of the rates, costs, and benefits of implementing identified energy conservation opportunities. These measurements are made in sufficient detail to allow analysis of the returns achieved by both the client firms after taxes and the federal government (tax revenues) on their respective investments in energy conservation as a result of the EADC program. The method used to calculate the rate of return is often called the discounted cash flow method but is also known as the interest-rate-of-return or the internal rate of return method. Calculating this rate of return by using the data collected in the implementation study shows that the client firms can expect to realize a 408.4% annual rate of return after taxes, while the tax revenues resulting from the firms' incremental earnings will represent a 105.9% annual rate of return to the government as a result of its investment in support of the program. Clearly, these returns compare quite favorably with those obtainable from normal investment instruments.

The data on which these calculations were based are shown in Table 3, which summarizes the costs incurred by the federal government and the client firms and the benefits which accrue from measured rates of implementing recommended ECOs. These data are stated in terms of the 151 energy audits covered by this report, rather than the total of the 171 energy audits actually performed. Therefore, the federal contract support has been pro-rated to $450,351, rather than the total contract amount of $510,000. The private sector development cost represents the estimated cost to the client firms of time spent participating in and analyzing the results of the EADC audit and choosing courses of action. Implementation costs are the total installed capital costs of all implemented ECOs, (determined separately

TABLE 3

1980 ENERGY AUDIT RESULTS - EADC PROGRAM

SUMMARY OF COSTS AND BENEFITS

COST		
Federal Contract Support	$ 450,351	
Private Sector		
Development Cost	20,844	
Implementation Cost	494,958	(1980)
	1,247,907	(1981)
	1,769,037	(1982)
BENEFITS		
Energy Savings from Implemented Conservation	1,006,611	(1981)
	1,784,305	(1982)
	3,388,944	(1983)

Inflation Rate 6% per year

Real Fuel Price Increase: 5.42 % per year

for each ECO); they are shown for ECOs implemented 0, 1, and 2 years after the audit was completed. Benefits from an ECO do not accrue until one year after implementation, and hence are shown for 1, 2, and 3 years after the audits. These benefits correspond to implementation rates of 32%, 51% and 86% in the years 1981, 1982, and 1983, respectively (based on measured implementation that was discussed in the preceding chapter).

In order to assess the rates of return for the client firms and the government, a table of cash flows (Table 4) was derived from the data in Table 3 by following these guidelines:

- Capital investments were financed at a 12% annual rate for 5 years and were depreciated linearly over a 5-year period to a scrap value of zero. (Without attempting to judge the legal merits of that depreciation rate, we used it because it imposes a higher annual cost for capital equipment and does not inflate the earnings rate of the investment).
- Fuel prices were increased at a composite rate of 11.75% per year because that is the compound effect of a 6% inflation rate and a 5.4% real price increase.
- Net cash flow in a year was defined as the difference between savings and cost, and this difference produces incremental earnings for the participating manufacturers that also increase their tax base.
- These changes in the tax base were assumed to be taxable at a 50% rate, so that the manufacturers' net gain was in fact only half the total savings. The other half became incremental tax income to the federal government.
- The federal government's investment of $450,351 contributed negative cash flow to the federal government in 1980, in addition to the tax revenues in that year.
- Cash flows are counted for 5 years after the capital investment is made to implement an ECO.

For each year, the net cash flow was used as input to a computer algorithm which solves the following equation for the equivalent interest rate:

TABLE 4

1980 ENERGY AUDIT RESULTS - EADC PROGRAM

CASH FLOWS, TAX RECEIPTS, EARNINGS

YEAR	PRIVATE SECTOR		NET CASH FLOW OR CHANGE IN TAX BASE	NET CHANGE IN FED. GOVT. TAX RECEIPTS	PRIVATE SECTOR EARNINGS AFTER TAXES
	Savings	Costs			
1980	0	158,150	-158,150	-79,075	-79,075
1981	1,006,611	438,488	523,123	261,562	261,562
1982	1,784,305	974,236	810,069	405,034	405,034
1983	3,388,944	974,236	2,414,708	1,207,354	1,207,354
1984	3,787,145	974,236	2,812,909	1,406,455	1,406,455
1985	4,232,135	836,930	3,395,205	1,697,603	1,697,603
1986	4,729,411	490,748	4,238,663	2,119,332	2,119,332
1987	5,285,117	0	5,285,117	2,642,559	2,642,559

Initial Federal Investment: $450,351 in 1980.

Private Sector Rate of Return: 408.4%

Federal Return (Based on Federal Investment & Taxes): 105.9%

To calculate rates of return:

$$CF_0 + CF_1 (1+i)^{-1} + CF_2 (1+i)^{-2} + \ldots + CF_n (1+i)^{-n} = 0$$

$$CF_0 + CF_1 (1+i)^{-1} + CF_2 (1+i)^{-2} + \ldots + CF_n (1+i)^{-n} = 0$$

where: CF_0 = initial investment

CF_n = cash flow, year n

i = equivalent interest rate.

When this equation was solved for i with private sector data (Table 4) the equivalent interest was 408.4%.

When this equation was solved for i with federal government data (Table 4), the equivalent interest rate was 105.9%.

In summary, the EADC program continues to show substantial returns for both the federal government and client firms on their investment in energy conservation.

Mr. FUQUA. Yes, we will. Thank you very much, Dr. Kirsch.

STATEMENT OF DONALD F. JORCZAK, PRODUCT MANAGER, ENERGY RECOVERY DEPARTMENT, DRESSER INDUSTRIES, INC., ACCOMPANIED BY ARDON B. JUDD, JR., STAFF VICE PRESIDENT AND WASHINGTON COUNSEL, DRESSER INDUSTRIES, INC.

Mr. JORCZAK. Thank you, Mr. Chairman and committee members, for the opportunity to address your committee. I am Don Jorczak, product manager for the Energy Recovery Division of Dresser Industries. I am joined today by Dresser staff vice president and Washington counsel, Ardon B. Judd, Jr.

I would like my entire statement entered into the record, but I wish to summarize it verbally.

Mr. FUQUA. Yes, that will be done.

Mr. JORCZAK. We would like to respond to some of the questions raised on the proper Federal role in promoting improvements in energy end-use efficiency, the barriers to investment in these technologies, the effect of decontrolled markets, the success of DOE programs, and the effect of terminating some DOE funding.

We believe that there are both proper and improper roles for Government involvement in the field of industrial energy conservation.

We feel criteria to be considered for a proper role are, one, the end result must have great promise to cost effectively conserve energy; and, two, the technology involved must be so new or risky as to preclude private industry from risking investment capital, or the project cost is so great that private industry cannot structure the financing.

A keyword in the first criteria is "cost effective." The end result must have an expectation that the marketplace will be ready to accept this technology on a cost-benefit comparison by the time its technical workability is demonstrated. It does the taxpayer little good to have paid to have developed something that is interesting but has no near-term practicality.

Dresser Industries is a strong supporter of industrial energy conservation. We practice conservation in our manufacturing plants, and we manufacture many types of equipment for this purpose.

My division entered a new market for us a little over 2 years ago. This market involves the design and selling of waste heat recovery systems that engineers call organic rankine bottoming systems. Simply put, you put waste heat into these systems and you get useful mechanical work or electrical power out. These systems are not new, nor do they involve any risky technology. In fact, the Rankine cycle is a relic of the age of steam. Replacing steam with an organic fluid in the system is hardly novel and has been a proven technology for decades. What is new is that the cost of energy has been rising faster than the cost of equipment for the past few years, and now the installation of this type of energy conservation system has become cost effective for some industries.

As do most companies who compete in the marketplace, we are constantly searching for new products to develop and new markets to serve. We carefully analyze investment opportunities and are eager to reinvest some of our earnings in new-business ventures. That is why Dresser decided to enter the organic rankine cycle system business, using its own capital for the research and development, manufacturing, and sales. We recognized that the marketplace would be able to justify the cost of buying these systems by the time we had them ready to sell. We have at least a half a dozen competitors who recognized the same opportunity.

The intervention of Government into this competitive product-development process distorts the marketplace and can actually be harmful to encouraging private investment which is the precise opposite of your desired goals.

For example, consider these three goals: You want industry to believe that installing this equipment is cost effective; however, critics will say that it was only installed because DOE subsidized the cost. It might have been justified anyway, but will we really know? Was the installation of DOE-subsidized equipment the best way to do the job? Well, again, not necessarily. One might have chosen differently without the DOE subsidy in the picture.

You want manufacturers to be encouraged to develop competitive equipment for this market; however, they will not if they have to try and sell against DOE-subsidized competitors.

This is exactly the position my company finds itself facing. One of our several competitors had their design funded by the DOE on a cost-sharing contract, and now has a commercialization contract to subsidize their selling price against the rest of us. The recipient of these contracts was the Sundstrand Energy Systems Co., and the commercialization contract alone involves $3 million of taxpayers' money.

Aside from the basic unfairness of such a contract where several companies compete in the same market, the contract subsidized the development of well-known technology that private industry was ready to develop in on its own. Just because there does not appear to be a certain type of equipment on the market, does not mean private industry is not working on it. Industry often conceals its R. &. D efforts to protect proprietary data. More commonly, we are simply waiting for the marketplace to be able to justify the in-

vestment on a cost-benefit basis. We believe that attempts to commercialize a product before the marketplace is ready will largely fail. When the marketplace has determined that the installation is cost effective, private industry will jump in and happily use its own investment capital and not taxpayers' money.

We believe that the decontrol of markets, especially the remaining price controls on natural gas, is a powerful incentive for private investment. Tax credits for energy conservation are also powerful incentives. Both of these incentives treat all competitors equally, and those with the most insight, initiative, and ambition will be the most successful.

I ask you to carefully consider before funding any new projects, that they show both excellent cost-effective promise and that they involve technology that is so new, risky, or costly that private industry cannot develop it with private capital.

I also ask you to scrutinize past contracts for technical merit and withdraw funding of wasteful or harmful contracts, including the Sundstrand commercialization contract. Give us a chance to compete for a return on our investment.

Thank you.

[The prepared statement of Mr. Jorczak follows:]

Statement by D. F. Jorczak
Dresser Industries, Inc.
Before House Subcommittee on
Energy Development and Applications
March 11, 1982

Chairman Fuqua and committee members, thank you for the opportunity to address your committee. I am Don Jorczak, Product Manager for the Energy Recovery Division of Dresser Industries. My operation is based in Houston, Texas. I received an engineering degree from Rensselaer Polytechnic Institute and have spent over 20 years in industrial application and sale of Heat Power and Energy Conversion equipment. I am joined today by Dresser's Staff V.P. and Washington Counsel, Ardon B. Judd, Jr.

We would like to respond to some of the questions you raised in your invitation to us to speak before this hearing. You asked us to comment on the proper Federal role in promoting improvements in energy end use efficiency, the barriers to investment in these technologies, the effect of decontrolled markets, the success of DOE programs, and the effect of terminating some DOE funding.

We believe that there are both proper and improper roles for government involvement in the field of industrial energy conservation.

A proper role would, in our opinion, have to be a situation that meets both of these criteria:

95-882 O—82—10

1. The end result must have great promise to cost effectively conserve energy.

2. The technology involved must be so new or risky as to preclude private industry from risking investment capital, or, the project cost is so great that private industry cannot structure the financing.

Not very many proposed or currently funded programs could meet both these criterias.

The key words in the first criteria are "cost effective". The end result must have an expectation that the marketplace will be ready to accept the technology on a cost-benefit comparison by the time its technical workability is demonstrated. It does the taxpayer no good to have paid to develop something that is interesting but has no near-term practicality.

Dresser Industries is a strong supporter of industrial energy conservation. We practice conservation in our manufacturing plants, and we manufacture many types of equipment for this purpose. My division entered a new market, for us, a little over (2) years ago. This market involves the design and selling of waste heat recovery systems that engineers call "Organic Rankine Bottoming Systems". Simply put, you put waste heat into these systems and get useful machanical work or electric power out. These systems are not new nor do they involve any risky technology. In fact, the Rankine cycle is a relic of the age of steam. Replacing steam with an organic fluid in the system is hardly novel and has been proven technology for decades. What is new is that cost of energy has been rising faster than cost of equipment for the past few years,

and now the installation of this type of energy conservation system has become cost effective for some industries.

As do most companies who compete in the marketplace, we are constantly searching for new products to develop and new markets to serve. We carefully analyze investment opportunities and are eager to reinvest some of our earnings in new business ventures. That is why Dresser decided to enter the Organic Rankine Cycle System business, using its own capital for the research, development, manufacturing, and sales. We recognized that the marketplace would be able to justify the cost of buying these systems by the time we had them ready to sell. We have at least a half dozen competitors who saw the same opportunity.

The intervention of government into this competitive product development process distorts the marketplace and can actually be harmful to encouraging private investment, the precise opposite of your desired goals.

For example, imagine that you are a company who is considering installing a waste heat recovery system and you have two proposals. One fits your needs very well but is quite expensive. The other doesn't fit as well but has a DOE subsidy that makes its much less expensive. You decide the price differential more than offsets the disadvantage of the poorer fit, and you decide to buy the DOE subsized unit. What has been proved?

1. Will industry as a whole believe you found installing this equipment to be cost effective? Not necessarily, since critics will say you only put it in because DOE subsidized the cost. You might have put it in anyway, but we'll never know.

2. Was the system you selected the best one available? Not necessarily, again for the previous reason. You might have chosen differently without the DOE subsidy in the picture.

3. Will other manufacturers be encouraged to develop competitive equipment for this market? If they have to sell against a DOE subsidized competitor, what do you think?

Mr. Chairman and committee members, that is exactly the position my company finds itself facing. One of our several competitors had their design funded by DOE on a cost-sharing contract and now has a commercialization contract (DE-FC07-80CS40340) to subsidize their selling price against the rest of us. The recipient of these contracts was the Sundstrand Energy Systems Company, and the commercialization contract alone involves $3 million of taxpayers money.

Aside from the basic unfairness of such a contract where several companies compete in the same market, the contracts subsidized the development of well-known technology that private industry was ready to develop on its own. Just because there doesn't appear to be a certain type of equipment on the market doesn't mean private industry isn't working on it. We often conceal our R & D efforts to protect proprietary data. More commonly, we are simply waiting for the marketplace to be able to justify the investment on a cost-benefit basis. The history

of these contracts shows that attempts to commercialize a product before the marketplace is ready will largely fail. When the marketplace has determined that the installation is cost effective, private industry will jump in with both feet and will happily use its own investment capital and not taxpayers money.

We believe that the decontrol of markets, especially the remaining price controls on natural gas, is a powerful incentive for private investment. Tax credits for energy conservation are also powerful incentives. Both of these incentives treat all competitors equally and those with the most insight, initiative, and ambition will be the most successful. That's the American way.

I ask you to carefully consider before funding any new products, that they show both excellent cost effective promise, and that they involve technology that is so new, risky, or costly that private industry can't develop it with private capital.

I also ask you, in reviewing the Energy Department's budget, to withdraw funding of wasteful or harmful contracts including the Sundstrand commericalization contract. Give us a chance to compete for a return on our investment.

We are with you in desiring to encourage industrial energy conservation. We are also with you in your efforts to reduce budgets and assure that the taxpayers get the very best value for their money. Mr. Chairman and committee members, you can

trust American industry to be very wise about anticipating opportunities to invest in industrial energy conservation. The free and competitive marketplace is very efficient. We have the capital, initiative and desire to do what's needed when it's needed and only ask that you let us fairly compete for the right to do so.

Thank you for this opportunity to express our views.

Mr. FUQUA. Thank you very much, Mr. Jorczak. I appreciate the testimony of all the witnesses.

The last comment that you made, Mr. Jorczak, about Government-subsidized products in the marketplace— of course, that concerns us also—has your company ever lost a head-to-head competition with Sundstrand?

Mr. JORCZAK. Yes, we have. We recently bid head-to-head with them on a project to recover waste heat with one of these organic Rankine systems from engines in a gas compression station in west Texas. Sundstrand offered the DOE subsidy and received a commitment on that project.

Mr. FUQUA. Haven't you won over them, too, though?

Mr. JORCZAK. I don't know where your information on that comes from. We have not won over Sundstrand on any contract.

Mr. FUQUA. It is my understanding that there was a Michigan-Wisconsin pipeline company that in a head-to-head competition you came out ahead. Then they decided not to go through with it.

Mr. JORCZAK. It is correct that we did bid head to head with Sundstrand on a project for a Michigan-Wisconsin pipeline company. We never received any commitment of any sort on that contract. It is correct that our understanding currently is that project is not going to proceed or is not likely to proceed, but we never received a contract.

Mr. FUQUA. The one you were referring to in Texas is the American National Gas Pipeline?

Mr. JORCZAK. No. There were two projects, one for American Natural Resources and one for National Gas Pipeline of America—different operations. The Natural Gas Pipeline Co. of America project is under evaluation. We did bid competitively, and there has been no award at all on that project. It is still under engineering consideration.

Mr. FUQUA. That hasn't been awarded?

Mr. JORCZAK. No; but we have lost a job that we bid head to head recently where the commitment was given to Sundstrand. They did offer the DOE subsidy.

Mr. FUQUA. Is that the only occasion?

Mr. JORCZAK. That is the only occasion that I personally know of.

Mr. FUQUA. Yes. However, in the Michigan-Wisconsin case you did come out ahead of them in your proposal.

Mr. JORCZAK. There was no commitment.

Mr. FUQUA. I know, but were you selected in a competition and then other things happened not related to that?

Mr. JORCZAK. I don't know how you would know whether you were selected if you don't receive a commitment from someone. There was no commitment made to anyone on that project.

Mr. FUQUA. Yes.

Mr. JORCZAK. It was under evaluation, and then it was delayed for a while, and then the last word we heard was that it was indefinitely shelved.

Mr. FUQUA. DOE, I think, initiated their contract with them in 1975, and also with MTI and Thermo Electron. Were you in the marketplace at that time?

Mr. JORCZAK. No, we were not. At that time, 1975, we had conducted studies of potential areas for energy conservation and the type of equipment that would be involved, and that included the type of system we are talking about, this organic Rankine bottoming system.

Mr. FUQUA. Yes.

Mr. JORCZAK. At that time, we did not proceed with the product development. I was not with Dresser at that time, but I am told that the feeling was that the cost of the equipment and the cost of energy at that time did not provide a cost-effective basis for its use. They decided that the market wasn't ready.

The oil embargo was just over, and we were like we are now. We had plenty of product and everybody was very happy.

The free-market system presents a challenge to industry to see who is the smartest about foreseeing and anticipating what is going to happen, how much risk are you willing to take. Those that are smarter about that, reap the rewards. That is sort of the A erican way.

Mr. FUQUA. Right.

Mr. Bailly, you mentioned that the Japanese were spending 147 times the amount that the United States is spending on industrial conservation R.D. & D. Was that based on the 1982 request of $1 million or the amount appropriated by Congress which was $29 million?

Mr. BAILLY. My statement was that it was 147 times for all five countries combined. The comparison is based on the $1 million figure.

Mr. FUQUA. It is based on the $1 million.

Mr. BAILLY. Yes.

Mr. FUQUA. You also described that the Economic Recovery Act would not provide industry with the sufficient incentive to accelerate R.D. & D. in energy production. How can you be sure that Government cost-shared R. & D. will succeed where tax incentives fail?

Mr. BAILLY. Well, let me tell you how we conducted the analysis. What you are trying to do is to simulate a cash flow which would accrue to the developer of these technologies, and that is what we tried to do. To do that, of course, you need to simulate the market penetration of these technologies over an extended period of time. In this case, we used 20 years.

Basically, after that, we tested the likely impact on the cash flow of the Economic Recovery Tax Act in terms of additional investment tax credit, R. & D. credits, and things of that nature.

Our conclusions were strictly based on what the simulation showed us, which was that in all four cases the Economic Recovery

Tax Act improved only slightly the internal rate of return which would accrue to the developer. The internal rate of return was still substantially below what the developer would want to compensate for that risk.

As I mentioned in my statement, for instance, the ceramic recuperator has a probability of failure of some 70 percent. Obviously, you need to compensate for that risk of failure. If the project were totally risk free, an individual company might be willing to live with an internal rate of return substantially less than the rate it would want if the project were highly risky.

Therefore, that is what we did. We simulated this sort of behavior. Let me give you, as an example, what we found. In the case of the ceramic recuperator, without ERTA, the before-tax internal rate of return was 56.8 percent. With ERTA, it was 60.9 percent. Therefore, there is not much of an inducement to take on the risk.

Now, if you look at the risk-adjusted internal rate of return which the developer would expect, it is about 2.5 times below what the developer would look for in this particular case to compensate for the fact that there is only a 32-percent chance that his project will actually meet his economic and technical expectations.

Mr. FUQUA. My time has expired, but I just want to ask Mr. Lawrence if you would comment on the last question I asked?

Mr. LAWRENCE. This is a comment on how the tax incentives would work?

Mr. FUQUA. Yes.

Mr. LAWRENCE. I guess, if I can state it——

Mr. FUQUA. Do you think they are better than direct Government involvement, or why would they not be better?

Mr. LAWRENCE. Yes, certainly. I think, from our own viewpoint, Mr. Chairman, you are looking at a high-technology company that considers itself highly creative and innovative. Our profit against our $60 million income is about $2.5 million. This year, it is going to be substantially less than that in profit because of the economy. The question is how much do we actually have to invest in R. & D.?

A tax credit does very little for us because you have to have an increased profit, and then expend that in R. & D. to get anything back, and that would still be a small increment compared to what we do.

I am afraid that for people like us who go after the longer term, higher risk nationally beneficial kinds of things, the Federal involvement is important for our innovations to continue.

Mr. FUQUA. Mr. Jorczak, would you mind giving you thoughts on that?

Mr. JORCZAK. We feel that the use of tax credits, the deregulation of markets, and accelerated depreciation, R. & D. credits, are incentives which are not only powerful incentives but they treat all companies who are competing in the marketplace equally. They all have an equal opportunity to use their smarts to develop products. They accelerate the cost-benefit justification of energy conservation equipment in the user industries. We advocate that approach rather than spotty here and there, direct subsidies to particular companies.

Mr. FUQUA. Thank you.

Mr. Dunn?

Mr. DUNN. I think it is very difficult to take different economies and different cultures and different histories, and say that what has worked in one country will work in the United States.

Mr. Bailly, you used some statistics from other countries, primarily Japan. If you take a look at the history of our country over the last 10 years, I think you will discover that, as Government involvement in our daily lives and in business and research and social programs has grown, the incentive for businesses to invest in their own future and research and development has decreased.

You might be able to make a different scenario in the case of Japan in the example you used where there is a lot of government involvement. Nevertheless. I do not think those kinds of things apply in this country.

I think it is very early in analyzing the effects of the new tax incentives and packages that were recently passed to simply say that they are not going to work. We do face a overwhelming budget deficit. That budget deficit does impact on businesses and their ability to borrow new funds and their ability to recapitalize.

Therefore, to say that the President's package will not work just because something happened in Japan is probably erroneous.

I do have a question for Mr. Kirsch. How much money did it cost to perform audits at 26 companies?

Dr. KIRSCH. Let me correct this. There have been 339 plants served. Twenty-three follow-up interviews were made during 1981 to ascertain client satisfaction—and that is all they did; the audits had been done. In other words, audits were done in 171 plants and we sampled 23 of them to ascertain client satisfaction. That is what I was trying to communicate.

Mr. DUNN. How much did it cost?

Dr. KIRSCH. The total cost of an energy audit by this program is a little under $2,000 on the average.

Mr. DUNN. How much did your program cost the taxpayers?

Dr. KIRSCH. The total cost for the 1980–81 phase of the program was—let me get my numbers right here. Well, I am sorry. I don't think I can give you that exactly. The total cost today for the 339 audits which I am describing here has been about $1.16 million since 1976.

Mr. DUNN. Aren't there private companies that could do that kind of audit?

Dr. KIRSCH. There are private companies that can. I personally know of four that are in chapter 11 that tried.

Mr. DUNN. I know of a company in my district that is doing it on a regular basis.

Dr. KIRSCH. Yes. What I am trying to say is that ones I know that have failed have tried in the medium and small manufacturers market. If they provide a breadth of engineering services, that is one thing. That gives them a broader spectrum of business services. On energy audits alone, they seem unable to make it.

Mr. DUNN. I thank the chairman.

Mr. FUQUA. Thank you, Mr. Dunn.

Mr. Fish?

Mr. FISH. Thank you, Mr. Chairman. I welcome the panelists.

Mr. Bailly, in your testimony, you indicate the need for federally supported industrial R. & D. since you believe that higher energy

prices coupled with the newly passed tax incentives will not provide enough inducement for the private sector to develop new energy technologies.

Should the Federal role in this area be restricted to a generic, high-risk research rather than applied research or demonstration activities; and, if not, why not?

Mr. BAILLY. The first problem, of course, is to define the meaning of high-risk generic research. I have been in this business for 10 years and I have yet to be able to handle it.

What might be perceived as a high-risk project by Dresser Industries, for example, might be very different for MTI. It depends really on the type of company. It depends on the company's willingness to take on risks.

My personal preference would be to restrict Government support to areas of so-called new technology development, high-risk development, excluding improvement of commercially available products.

However, as I explained in my testimony, there is another aspect, which has to do with the competitiveness in global markets. There I see a role for the U.S. Government, which could go beyond high-risk technologies and provide subsidized loans, for example, to industry to develop and market their technologies—energy-efficient technologies—like the Japanese do, like the French do, like the Germans do, for example.

There is one aspect which has to do with research and development and another one which, in my mind, has to do with competitiveness in the global market. My answer depends on whether the focus is a domestic one or a global market one.

Mr. FISH. Yes.

Mr. Lawrence, would you like to comment on that?

Mr. LAWRENCE. Yes. Again, it is a difficult question to answer in terms of what is generic R. & D. and what have you. I think from my own perspective, Mr. Fish, what we see is a situation where in the Defense Department in this country, they have figured out how to stay ahead of the competition technologically. It is done through research, followed by exploratory development, advanced development, product engineering, what have you, with a strong funding increment toward the basic research and the exploratory development and the advanced development.

These are things that they do not expect in the military to have ready for 10 years. Now, we have done a similar thing in NASA which has built our aerospace industry to be world dominant.

The countries like Germany, Sweden, Japan, France, Italy, what have you, are emulating this in the commercial sector, in the consumer product sector, and in their industries. For instance, I just got a Japanese news release a week or so ago showing that MITI has put into place a 9-year well-funded program in a given technology, and they don't even expect this to be in the marketplace for 9 years. Now, I just flat out don't know of an industry in the United States that would even conceive of doing something like that on their own—to put in place a program that wouldn't be in the marketplace for 9 years.

If we are going to compete internationally, we have got to figure out how to combat the foreign government industry team. The only

way I can see to do it is to take a NASA-type approach in the commercial sector and join together to be competitive.

Mr. FISH. With this next question, I will start with you, Mr. Lawrence, and then I will ask Mr. Bailly to comment.

The Department of Energy, in their testimony before us, stated that energy efficiency in the 10 most energy-intensive industries in the United States had improved by 17.6 percent between 1972 and 1980. They credited it to the increase in cost of energy during that time. The Department went on to say that the total effect of all Government actions in conservation to date had been relatively minor.

Do you gentlemen agree, or, if not, how would you respond to that?

Mr. LAWRENCE. Well, I guess I come from an interesting perspective here, Mr. Fish, because I was one of the first executives of ERDA back in 1975. I know the rationale under which we put a lot of these original programs in place. Now, I have been in the private sector for about 5 years, so I have the vision from that side of the table as well.

When ERDA was put into place, we did not expect to see any results for about 5 years which would have been 1980 when things would have been entering into the marketplace. I can remember that at that time we were saying that by 1985 such-and-such savings would be in place.

I have seen, in the results of DOE programs, some things which are now rapidly expanding into the marketplace. For instance, out of the industrial programs, the coil-coding process is one that is talked about an awful lot. That thing was developed. It was demonstrated, and the industry went after that like crazy once they saw that it was a viable technology and when put into their processes, it wouldn't shut the process down in an uncontrolled fashion.

We have seen this also with other technologies. I know that they mentioned Litek here today—the high-efficiency bulb.

I know that in the sunset review that I mentioned before there are a list of others.

I think what you have to say is that, looking back at those objectives in 1975 and 1976 that were set, I think that ERDA and the Department, has been remarkably successful; under all kinds of severe handicaps, by the way, of management going in and out like crazy and now people at the top who don't even believe in the programs, and they are running the Department.

Somehow, now that in the past year all of these budgets have been crunched way down and the tough hard decisions have been made, the things that are there under the appropriations are surviving because they were given extreme scrutiny and survived. I think that core has got to be maintained and built upon.

We have learned an awful lot in 7 years, and there are an awful lot of good things that have come out as well as the criticism. We need to maintain that thrust.

Mr. FISH. Thank you. I guess my time has run out. I can't get to you, Mr. Bailly.

Mr. FUQUA. Mr. Gregg?

Mr. GREGG. Thank you, Mr. Chairman.

Dr. Kirsch, you made the point these are energy audits that the Government should be doing because the small companies can't afford to do them.

Are energy prices or interest rates affecting small companies more today?

Dr. KIRSCH. Well, we are seeing an increased energy cost so that energy is not only increasing in dollars but as a share of total manufacturing costs. Whether you look at it in terms of manufacturing costs alone or gross sales or whatever, energy costs are going up.

What we have seen in the past 2 years in particular is a rapid shift away from fuel oil, for example, which is brought on by its price.

Mr. GREGG. Well, that is really not responsive to the question. What I was asking was what was having the most negative impact on earnings of small business today, interest rates or energy costs?

Dr. KIRSCH. It is both. The interest rate is there. Look, the small businessman, as we both recognize, deals mainly in cash flow. Whatever impacts cash flow harrasses business.

Mr. GREGG. Haven't we seen a stabilization of the cost of oil over the last year?

Dr. KIRSCH. We have seen a stabilization in the cost of oil. Yes.

Mr. GREGG. Have we seen a stabilization in the interest rates over the last year?

Dr. KIRSCH. No.

Mr. GREGG. So I would have to assume that interest rates are having more of an impact on the cash flow than energy costs, aren't they?

Dr. KIRSCH. Yes; I have no quarrel with that. I am saying that whatever impacts cash flow is a problem for him, and the interest rates also indirectly affect his energy costs.

Mr. GREGG. Well, my point is in an economy where the thing that is having the most impact on the small businessman is the interest rate, since we have stabilized energy costs as a result of the oil deregulation, that the odds are that if we can bring down interest rates, we are probably going to have a more positive impact on that individual than if we give him one or two programs that help him out in the energy area.

Dr. KIRSCH. Well, his energy hurts his competitiveness and this is uneven across the country. It varies a great deal from place to place.

The energy cost to the individual is important not only in terms of absolute dollars, but in terms of its effect on his competitiveness with his competitors in other parts of the country.

Mr. GREGG. So you are saying that as long as the high interest rates are consistent across the country, it really doesn't matter that much to the small businessman who just went out of business——

Dr. KIRSCH. No.

Mr. GREGG [continuing]. Whether it was in New England or——

Dr. KIRSCH. No; that is not what I am trying to say. I am just trying to say that his energy costs are a continuing problem to him. They have been an increasing problem to him. Especially in the period 1976 and 1977 when there were natural gas shortages in the marketplace at that time, there were some people who went

out of business because of that. Unless they were able to switch to alternate fuels, and we dealt with them, and helped them to switch to alternate fuels, they did encounter problems. Yes.

Mr. GREGG. Well, I would just submit that I think energy conservation is very important. I suspect, however, that the marketplace will have as much impact on conservation as the Federal Government's spending a few dollars here and a few dollars there on it.

Dr. KIRSCH. Well, the important point is that they don't have the expertise to do it. The people we deal with do not have the in-house expertise to do the job.

Mr. GREGG. Yes; but the people you deal with probably also don't have the ability to deal with 16 to 18 percent lending rates. What they really need is to bring down that interest rate and the only way we are going to get this interest rate down is when we bring this deficit down.

Dr. KIRSCH. Yes.

Mr. GREGG. Bringing this deficit down means that we are going to have to do something about the Federal spending. That is the issue for me. Thank you.

Mr. FUQUA. Thank you.

Ms. Schneider?

Ms. SCHNEIDER. Thank you, Mr. Chairman. I would like to approach almost the same issue from a little different angle with Mr. Jorczak. Besides deregulation of the market and the tax credits, are there any other Federal policy barriers that you can identify for me that encourage industrial energy conservation?

Mr. JORCZAK. Yes; dealing with the comments that have been made with international competition, we haven't seen a great deal of effect with the international funding of R. & D., but we have in the subsidizing of interest on export credit by other countries. The policies of other countries to do this have been much greater than the United States, and that has hurt our activities in international competition.

Domestically, there are some very large amounts of wasted energy in industry that can be saved, but it is encumbered with fluctuating Federal regulations, unnecessary regulations, and——

Ms. SCHNEIDER. Could you be specific, please?

Mr. JORCZAK. Well, I can give you a specific that solved and cut through a lot of these regulations which was the Public Utilities Regulatory Policy Act of 1978. This was a great help in reducing the conflicting and encumbersome regulation that was restricting private industry investment in energy conservation.

However, a recent court decision has set back implementation of that law possibly for several years. I would urge you to support implementation of your intent under that law.

Ms. SCHNEIDER. I would have to know a little bit more about that. How exactly did it impede?

Mr. JORCZAK. The Federal Energy Regulatory Commission is charged with enforcing that law. They issued rulings. Two of the rulings were struck down by the U.S. court of appeals just recently in February.

While that effect of striking down the two rulings is sorted out, it is going to cause industries which were going to go ahead and invest in energy-conservation equipment to withhold and hold back

on their investments, waiting to see what the effects of the rule are and what the game plan is they are going to have to play by.

It is really just knowing what a consistent set of rules are. The fact that they do not have conflicting things that they have to contend with is really a great incentive. We can play almost any game if we have a consistent set of rules.

Ms. SCHNEIDER. Well, let me just make a point. Coming from the Northeast, as Congressman Gregg also does, when we are talking about industrial energy conservation, I have a tendency to consider the operation of textile mills, machine tool shops, manufacturing plants, et cetera.

Granted that they have concerns with various policy barriers, and that they have problems with the high interest rates, one of the things that shocked me the most was to find out the areas where small businesses have a great deal of their problems. Small business is what really keeps this country rolling. In the two areas where they are having problems one is lack of information. They do not know about the latest technical fixes that are available. They are not familiar with any kind of cost-benefit analysis that may have been done on different technologies or what kind of savings might result.

The Department of Energy is certainly planning on eliminating their information-generating facility there, and I think that will certainly be cumbersome.

However, the other area that is of concern to them is access to capital. Once again, it is a situation where small businesses are not in a position to compete with big business. I think you are talking about big business competing against big business.

What are your thoughts as to accessibility of small business?

Mr. JORCZAK. I would really have to honestly say that I do not see any great distinction between the opportunities for large business and small business.

Ms. SCHNEIDER. Except that big business has easier access to larger amounts of capital; and, therefore, they can move ahead.

Mr. JORCZAK. Small business, if they have good ideas, also has access to capital because there is private capital. There is venture capital funding firms that are constantly looking for innovative ideas to back.

Mr. Lawrence said that his was a small company and was responsible for a lot of technical innovation. I would agree with him. They have done a marvelous job. My company, while it is fair to characterize it as large, it is really just a collection of a various large number of small businesses.

We have to compete for alternative capital financing within our own company on the same basis that a small company would outside. If a project or an idea that I propose to my management doesn't have the payout for their capital, they won't back it.

Ms. SCHNEIDER. I am afraid, I guess, that my time is up. Is that right? Thank you, Mr. Jorczak.

Mr. FUQUA. Thank you very much, Ms. Schneider. We do have another panel of witnesses and I don't want to inconvenience them by having them stay real late.

I want to thank all of our witnesses for being here today. We have seen that there is not altogether unanimity, but we do appreciate your being here.

Dr. KIRSCH. May I add one more comment? I am sorry that Mr. Gregg has gone, but the kind of program that I have been trying to describe is one we describe as a seed investment because I honestly believe—and our numbers show this consistently based on measured implementation—that the Federal Government gets its money back.

Mr. FUQUA. I think also there is another part to that which is very important, which is having a reliable energy supply for the future. That is as important as having money at an affordable price.

Thank you all very much for being here. We appreciate your contributions.

We are very pleased to have all of you here. While you are taking your seats, without objection, there will be permission to take photographs and other recordings of the meeting.

Ms. Bleviss, we will be pleased to hear from you at this time.

STATEMENT OF DEBORAH BLEVISS, ENERGY CONSERVATION COALITION

Ms. BLEVISS. Thank you, Mr. Chairman and the remaining members of the subcommittee.

I am here representing two organizations today: the Federation of American Scientists and the Energy Conservation Coalition.

The federation is a group of 5,000 scientists who have been active since 1945 in issues of science and its effects on public policy.

The Energy Conservation Coalition, in contrast, is a very new organization and it is a broad alliance of various public interest groups that represent a total of about 6 million individuals. The Federation of American Scientists is a member of the Energy Conservation Coalition.

Both of the organizations that I represent are quite concerned about the President's proposed energy conservation budget. We are concerned because the current budget levels are 97 percent cut below what they were when the President first took office. More than that, they represent a 95-percent cut below what was actually appropriated last year.

In particular, the reason why we are concerned is because we see conservation as a very necessary part of the national strategy, particularly to pull us out of our economic woes at this point.

I would like to point out that even though we are currently seeing a leveling off of oil prices and even though we are in the middle of an oil glut right now, oil prices today still remain in real terms eight times higher than what they were just before the Arab oil embargo and twice as high as they were before the Iranian revolution.

Moreover, in 1973 only 8.5 percent of our GNP was going toward retail energy expenditures. Today that figure has risen to 15 percent. If we had been investing in energy efficiency then, perhaps today more of our scarce capital resources in this country could be going towards more productive uses elsewhere.

The other thing I would like to point out is that when compared with other fuels, conservation is really the cheapest fuel we have, varying between $1 and $25 per barrel equivalent.

For these reasons and others, there is a real purpose to having an aggressive conservation policy in this country. We agree strongly that there is a value for having the market play a role. The market has already played a role in inducing the conservation we see today.

But there are major imperfections in the market which require some intervention by the Government. Four of these include: Research; information; overcoming particular institutional barriers in our society; and, finally, addressing the specific needs of the poor who do not have the capital to invest in conservation.

I would like to limit my testimony to the research and informational needs because they are the areas that are within the purview of this subcommittee.

The President, in providing us with a very reduced research and information budget for conservation, has said in effect that he believes that the market will accomplish most of the conservation research and information needs alone, that there is very little need for Government support.

I would like to counter that, particularly in the buildings area, by citing a recent survey that was undertaken just a few weeks ago in which the major buildings-oriented organizations—major trade associations, major utility research institutes, and a major company—were all consulted. These had been alluded to by the Department of Energy as organizations that were taking over where DOE was dropping out. We surveyed them to find out precisely what was happening. I might add that among those organizations were two here at the table: the homebuilders and the architects.

What we found out was astonishing, even to us. First of all, we found that among the utility research institutes which generally had the largest capital available for buildings research, the total amount of money that was being put into research just did not equal the level that DOE was, at one time, supporting. They were putting in levels on the order of tens of millions of dollars annually while DOE, at one point, had funding on the order of hundreds of millions. This was just the research undertaken by the utility institutes.

The other institutions, in general, either had declining budgets for research or their research budgets were staying about the same, after adjusting for inflation. In neither of those cases were they actually increasing their budget to compensate for the DOE cuts.

Finally, some of those organizations that were surveyed actually pointed out that in some ways they depended very intrinsically on the DOE research program because they took a lot of the guidance for priorities from the DOE research priorities.

The Energy Conservation Coalition and FAS have been so concerned about the change in the budget that we have submitted an alternative to the President's budget, which is attached to the testimony. I do not want to go through it in great detail. What I would like to do here is address the buildings end of it because this is a buildings panel.

I would like to preface a discussion of that budget by saying that this budget stays within the existing guidelines of the existing DOE program.

Also, FAS and EEC have been involved with the homebuilders, with AIA, and several other organizations in trying to design a comprehensive buildings research budget in energy which would include both conservation and solar and which the architects are going to address shortly. That program is what we would like to see eventually because it would be very comprehensive and it would correct some of the weaknesses that exist in the present DOE program. In the absence of this new program though, our alternative budget is what we are proposing.

Specifically, what we are suggesting is the following:

I consider the BCS program to be one of the most successful of the DOE conservation programs. Such developments as the house doctor approach to energy auditing, the solid state fluorescent light ballast, and the hot water heat pump have all been developed within the BCS program. Moreover, one particularly important aspect of the BCS program has been the whole study of indoor air quality. That is an area that private industry really has little concern with and rightly so, and it is definitely something that the Federal Government, in preserving the health of its citizens, must address.

We support strongly continued funding for building systems, community systems, small business—which was defunded last year—technology and consumer products, analysis and technology transfer, municipal and urban waste.

In particular, we would like to point to the analysis and technology transfer part of the program. As one area that always gets short shrift and which is, in essence, the basis of a good research program, we feel that program deserves to be revamped so that it can develop a good data and information base upon which to base the rest of the BCS programs, as well as to develop an evaluation component.

In addition, I would like to point out that, within the building systems subprogram, we would like to suggest that there be two additions to it which are major failings right now. One is the development of building energy performance guidelines so that consumers can receive the equivalent of an automobile MPG rating for the buildings they occupy whether they are renting or buying them. The second, just as important in the buildings research program, is the necessity of having sample demonstrations of energy conservation delivery systems. A critical element of buildings conservation is delivering conservation to the consumer and that has been a failing so far.

I would like to close my remarks at this point by urging the committee very strongly to consider our alternative budget and to consider the buildings energy research program that is going to be discussed later as critical areas in which the Federal Government must play a role.

Energy conservation is necessary to both our failing economy and also to mitigate the effects of our dwindling domestic oil reserves. Thank you.

Mr. FUQUA. Thank you very much, Ms. Bleviss. We appreciate your statement, a copy of which will be inserted into the record.

[The prepared statement of Ms. Bleviss follows:]

TESTIMONY ON
THE FISCAL YEAR 1983
ENERGY CONSERVATION BUDGET

Presented by
Deborah Lynn Bleviss
on behalf of
the
Federation of American Scientists
and the
Energy Conservation Coalition

Submitted to the
House Subcommittee on Energy Development and Applications
of the
Committee on Science and Technology
March 11, 1982

Mr. Chairman and Members of the House Subcommittee on Energy Development and Applications, I am here on behalf of the Federation of American Scientists (FAS) and the Energy Conservation Coalition (ECC) to testify on the fiscal year 1983 energy conservation budget. The Federation of American Scientists is a non-profit organization composed of 5000 natural and social scientists and engineers concerned about science and its impact on public policy, including 50 percent of the living American Nobel laureates. The Energy Conservation Coalition is a new organization formed by a broad alliance of public interest groups all of whom are dedicated to improving the efficiency with which our nation uses energy and who represent in total more than six million people. Members of the ECC include: FAS, the Conservation Foundation, the Environmental Defense Fund, the Environmental Policy Institute, Friends of the Earth, the League of Women Voters of the United States, the National Audubon Society, the National Consumer Law Center, the Natural Resources Defense Council, Environmental Action, the National Wildlife Federation, the Sierra Club, the Solar Lobby, the Union of Concerned Scientists, and the National Consumers League.

Both of the organizations that I represent are quite concerned about the drastic change in direction that federal funding for energy conservation has taken. The Administration's budget proposals for 1983 would cut federal conservation programs by an astounding 97 percent from the level they were at when the Administration first entered office. Moreover, the President's numbers also represent a 95 percent reduction in spending for conservation below what the Congress appropriated for fiscal year 1982--a truly disturbing reduction since Congress had already reduced conservation spending that year by 60 percent compared to fiscal year 1981. A chart is included with this testimony showing the magnitude of the cuts being proposed.

We believe these cuts are very ill-advised. They reverse a policy that Congress has wisely established in the years following the Arab Oil Embargo of 1973. And they ignore the mandate for conservation that the Congress has imbedded in at least 26 laws since 1973.

Permit me for a moment to review for you the reasons why Congress has in the past embraced energy conservation as a necessary component of national policy. First, energy conservation mitigates the harsh effect that high energy prices have on the national economy. Despite the present temporary oil glut and the also temporary reduction in oil prices, today's real energy prices remain more than eight times what they were just before the Arab Oil Embargo, and more than twice what they were just before the Iranian Revolution. Retail expenditures on energy in this country have increased from just 8 1/2 percent of GNP in 1973 to 15 percent in 1980. Had some of those expenditures been made instead on energy efficiency, today we could be spending our nation's increasingly scarce capital resources less on energy and more on productive uses elsewhere. Moreover, expenditures made on energy efficiency keep domestic capital at home, not flowing overseas to pay for foreign oil. Finally, when viewed as an energy resource much like oil and natural gas, energy conservation is the cheapest fuel we have, costing anywhere between $1 and $25 per barrel oil equivalent.

In addition to these points, energy conservation is the only short term hope we have as a nation for dealing with the fact that our own domestic oil resources are finite. By the Administration's own estimate in its National Energy Policy Plan backup documents, we can expect to find only about 69 billion barrels of conventional oil left in this country--this compares with Exxon's estimates of 45 billion barrels and Rand Corporation's estimates of 59 billion barrels. If we continue to consume domestic oil at the rate the

Administration is projecting, then by the turn of the century, we can expect at most ten more years of domestic oil supply. While the outlook is quite positive that alternative energy sources, most notably renewable energy, will eventually be able to satisfy our domestic needs for liquid fuel, most energy analysts agree that this will not completely happen within the next 20 years. Therefore this country must depend on an aggressive energy conservation program to postpone that day of reckoning so that we can have the alternatives ready.

But what does an aggressive energy conservation program consist of? As Congress has recognized in legislation passed over the last seven years, it must have four major components: (1) providing information to consumers of energy and the fledgling conservation industry alike about how to conserve; (2) supporting research on how to conserve energy so that the full potential for realizing energy efficiency in this country can be tapped; (3) overcoming institutional barriers in our society that work to discourage conservation (as the Schools and Hospitals Program, for example, is designed to do); and (4) addressing the problems of low income households who, caught by high energy prices, cannot afford to invest in conservation.

I would like to limit my testimony to the research and informational ends of the national conservation program because those are the programs over which this Subcommittee has jurisdiction. Let me first note that research and information are strongly tied to each other. The knowledge gained from research is useless unless the means are there for disseminating that knowledge. In a sense, information is a component of any research program. The Administration has claimed that the research and informational needs of a conservation program will be answered by the market alone, that there is no need for government support in this area. In response to these claims, I would like to relate to you the results of a survey recently undertaken to

determine whether private industry, in this case in the buildings sector, is picking up the research and information programs now being dropped in the Department of Energy. It is important to note here that the buildings sector, when compared with transportation and industry, is perhaps the most disaggregated, least centralized, and thus least able to conduct its own research or to develop its own informational system. The survey covered major trade and membership associations such as the National Association of Home Builders and the American Institute of Architects, utility research institutes, and a single large company, General Electric. The survey found that even the utility research institutes, which typically have the largest buildings research and information budgets, are not putting enough funds (although they are increasing) into this area to make up for what is being dropped in the Department of Energy (DOE). Specifically, funding is in the tens of millions rather than the hundreds of millions DOE supported in the past. In addition, most of the other institutions polled indicated that their research and information budgets are expected either to decline, or to stay the same, after adjusting for inflation, rather than to increase to cover the lost DOE support. Finally, several of those surveyed indicated that the loss of the DOE research and information programs will have a negative impact on their own programs -- because they took considerable guidance and support from the priorities DOE set. All in all, the evidence does not appear to support the claim that the market will pick up all buildings research and information needs. Similar cases can be made in the transportation and industrial sectors.

Before I turn to the specifics of the conservation budget, I would like to make one additional comment. The cuts in conservation proposed by this Administration will cause this country to fall far behind other world leaders in conservation research. According to a report prepared by dhr, Incorporated for the Department of Energy, prior to the Reagan Administration, the United

States had a medium ranking in conservation and solar research spending in both the public and private sectors, when weighted by energy consumption, in comparison with other leading countries in Western Europe--a fair but satisfactory performance. However, if the proposed conservation and solar cuts are approved, the U.S. will fall to the "bottom of the international 'league' in weighted terms and possibly behind other smaller countries even in absolute terms". Considering the concern we now have because the Japanese have cornered the market on energy-efficient cars, allowing this country to be surpassed in conservation R&D funding when compared with others could portend poorly for future balance of trade.

Now for the conservation budget itself. In response to its concern about the proposed Reagan conservation budget, the ECC and FAS put together an alternative budget, which I have included as part of this testimony. This budget adheres to the limits established by the Congress in the Omnibus Reconciliation Act of 1981, or an overall funding level, including the Solar Energy and Energy Conservation Bank, of $625.1 million. This proposed funding figure does not suggest that we believe this level of spending is optimal to assure an aggressive federal conservation effort; it merely reflects our acknowledgement of the budgetary problems the Congress is now facing. However, it is important to note that if there is any sudden or dramatic increase in current energy prices, significant funding increases in our proposed conservation budget will be necessary, particularly for programs like Low Income Weatherization and the Solar and Conservation Bank, which are specifically designed to enable low and moderate income families to adjust to these higher prices by investing in conservation.

When compared with the priorities established by Congress in both Reconciliation and the 1982 Appropriations, the overall funding in our

alternative budget for the Buildings and Community Systems Program is virtually the same. However, we support a higher funding level for the Industrial Energy Conservation Program and a lower level for the Transportation Energy Conservation Program than Congress has set. The work that has been carried out by these programs has for the most part been quite good, and has addressed areas that the private sector has been either unwilling or slow to pick up.

Within the Buildings and Community Systems (BCS) Program areas under this Subcommittee's jurisdiction, we strongly support funding for Building Systems, Community Systems, Small Business (which was defunded in 1982), Technology and Consumer Products, Analysis and Technology Transfer, and Municipal/Urban Waste. Without these endeavors, such developments as the house doctor approach to energy auditing, the solid state fluorescent light ballast, and the heat pump water heater would not have been achieved in a timely fashion. Moreover, the significant strides made in understanding how to mitigate the effects of indoor air pollution, a concern beyond the scope of private industry, would not have happened. The Analysis and Technology Transfer subprogram deserves special mention--it is quite important that this subprogram be revamped and given sufficient emphasis so that it is able to develop a data and information system to support the rest of the BCS program, as well as to evaluate its performance. A sound data base and evaluation are necessary components to any successful program. Finally, we urge the committee to expand the tasks to be undertaken within the Building Systems subprogram to include the development of building energy performance guidelines so that consumers can receive the equivalent of the automobile "MPG" rating for buildings, as well as demonstrations of energy conservation delivery systems to test how best to deliver conservation to consumers. These, we believe, are necessary components of a good buildings research program.

Within the Industrial Energy Conservation Program, we support strongly funding for Waste Energy Reduction, Industrial Process Efficiency, and Industrial Cogeneration, all of which have made significant strides in accelerating the rate at which energy efficiency improvements are being made in today's industrial sector. We also support strengthening the Implementation and Deployment subprogram to include not only support for the six Energy Analysis and Diagnostic Centers, but also support for analysis of the market potential in industry for the new energy-conserving technologies now being developed, dissemination of information on new processes and technologies to relevant industries, and analysis of the overall effectiveness of the Industrial Energy Conservation program. While the market plays a larger role in the industrial sector as compared with the buildings sector in promoting private sector research (at least in large industries), it remains deficient in information outreach.

Within the Transporation Energy Conservation Program, we support funding only for basic research on electric and hybrid vehicles, and Stirling and Brayton engines rather than the demonstration emphasis we have heretofore seen. In addition, we support the development of a cooperative research program with the automobile industry on such short-term but fast payback research areas as direct-injection stratified-charged and diesel engines, advanced transmissions, lubricants, and tires. We also support increased emphasis on the Alternative Fuels Utilization subprogram in order to develop substitutes for our finite oil supplies, specifically on research to develop methanol- and ethanol-propelled vehicles. Finally, we believe special mention should be made of the Transportation Systems Utilization subprogram which addresses work that undoubtedly will not be addressed at all by the private sector. Outreach efforts in this subprogram which should continue include

information on low cost/no cost motor vehicle conservation, gas mileage of new car fleets, and methods to increase the efficiency of transportation systems, be they rail, marine, air, ground, or pipeline.

Within the Multisector area, we support continued funding for the Energy Conversion and Utilization Technology, Inventors, and Appropriate Technology Programs, all of which deal with needs the market does not answer.

Finally, lest we not forget the one program in the state and local category which falls in the Subcommittee's jurisdiction, the alternative budget maintains strong support for the Energy Extension Service. The successful use of this program, most notably in California and Minnesota, to support unanswered research and outreach needs argues strongly for its continued funding.

Both the Federation of American Scientists and the Energy Conservation Coalition strongly urge the Subcommittee to support the alternative budget I have outlined for you here today, and to embody its recommendations in any action you take on the budget. Energy conservation is a necessary component of any national strategy to heal our ailing economy and to cope with our diminishing domestic energy supply. But it cannot depend on the market alone to ensure its implementation. The market will not answer all research and informational needs, it will not overcome all institutional barriers, and it will not answer the special problems of the poor. Continuing federal support for the research and information programs within your jurisdiction must remain part of the overall national strategy to implement conservation.

(IN MILLIONS OF DOLLARS)

	FY 81		FY 82		FY 83
DEPARTMENT OF ENERGY (DOE)	pre-rescission	post-rescission	reconciliation 1/	appropriation	Reagan
BUILDINGS AND COMMUNITY SYSTEMS	113.8	76.8 2/	77.6 2/	47.7	0.0 4/
INDUSTRIAL ENERGY CONSERVATION	89.7	68.9	32.1	28.8	0.0 4/
TRANSPORTATION ENERGY CONSERVATION	119.7	99.0	64.3	58.9	0.0 4/
STATE AND LOCAL	452.9	404.7	331.0 2/	284.2 3/	4.3
MULTISECTOR	26.5	26.5	20.0	16.5	17.5 4/
DOE SUBTOTAL	802.6	675.9	545.1	386.1	21.8
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)					
SOLAR AND CONSERVATION BANK	123.0	0.0	50.0	23.0	0.0
HUD SUBTOTAL	123.0	0.0	50.0	23.0	0.0
TOTAL	925.6	675.9	595.1	409.1	21.8

1/ The Omnibus Budget Reconciliation Act of 1981; Conference Rept. No. 97-208
2/ Includes Urban Waste and capital equipment
3/ Includes Energy Extension Service
4/ Small remnants of each program have been lumped into the single multisector category

Prepared by:
David Moulton
Energy Conservation Coalition

January 1982

SUMMARY OF ECC'S
PROPOSAL FOR ALLOCATING THE RECONCILIATION BUDGET
FOR FEDERAL ENERGY CONSERVATION PROGRAMS
FY 1983
(in millions)

DEPARTMENT OF ENERGY	fy 82 Appropriation	fy 83 Reagan	fy 83 Reconciliation 1/	fy 83 Proposed
Buildings and Community Systems	47.7	0.0	81.8	78.8
Industrial Energy Conservation	28.8	0.0	33.9	42.7
Transportation En. Conservation	58.9	0.0	68.0	43.0
State and Local	234.2	2.5	370.3	393.0
Multisector	16.5	19.7	21.1	17.6
DOE Subtotal	386.1	22.2	575.1	575.1
DEPARTMENT OF HOUSING AND URBAN DEVEL.				
Solar and En. Conservation Bank	23.0	0.0	50.0	50.0
HUD Subtotal	23.0	0.0	50.0	50.0
TOTAL	409.1	22.2	625.1	625.1

1/ Derived by adjusting each program upwards by the same proportional increase approved by Congress in Reconciliation

Highlights:

* Proposed budget has been held within the $625 million in BA that Congress approved during Reconciliation

* DOE priorities would be shifted to provide a more balanced approach to overcoming the full range of barriers to a more effective market:

	PERCENT OF TOTAL	
	fy 82 Appropriation	Proposed for fy 83
BUILDINGS & CS	12.4	13.7
INDUSTRIAL	7.5	7.4
TRANSPORTATION	15.3	7.5
STATE/LOCAL	60.2	68.3
MULTISECTOR	4.3	3.1
	100.0	100.0

* 70 percent increase in State/Local, including $234 million for low-income weatherization

* $50 million to leverage loans from the Solar and Energy Conservation Bank to middle and lower-income households

* Total federal energy conservation budget is still only at the same level as fy 81 post-rescission budget

* Still 37 percent <u>below</u> the fy 81 pre-rescission budget

Prepared by David Moulton of the Energy Conservation Coalition (797-6390) and Debbie Sleviss of the Federation of American Scientists (546-3300)

Department of Energy

PROGRAM: Buildings and Community Systems

(in millions)

SUBPROGRAMS	FY 82 Appropriation	FY 83 Reconciliation	FY 83 Proposed
A) Building Systems	18.6	24.8 +	27.0
Projects to include:			
1) Applied research in new and old buildings.			
* 2) Development of building performance guidelines, including energy labeling, with manuals and support to states on both labels and voluntary standards.			
3) Evaluation of new construction practices and the existing building stock and its rate of retrofit.			
* 4) Grants for demonstrations of energy conservation delivery systems, especially for rental housing.			
B) Residential Conservation Service (RCS)	3.4	+	10.2
Projects to include:			
1) Evaluation of and technical assistance with state RCS programs.			
2) Monitoring of utility supply, installation, and financing activities.			
* 3) Preparation and development of the Commercial and Apartment Conservation Service program (CACS).			
* 4) Grants for training and certification of energy auditors.			
C) Community Systems	3.8	4.6	4.0
Projects to include:			
1) Cogeneration and district heating applications to communities.			
* 2) Community outreach.			
* 3) Community energy management planning.			
D) Small Business	0.0	0.0	1.0
Projects to include:			
* 1) Evaluation of technologies applicable to small businesses which will reduce energy use.			
* 2) Outreach to small businesses to reduce energy use.			

+ indicates that this subprogram was expected to receive an additional, unspecified amount out of $27.1 million in new BA in 1982 provided by the Reconciliation Act for B & CS and TSU. (We assumed an allocation of 3.3 to TSU, and have adjusted upwards proportionately for FY 83.)

Department of Energy

PROGRAM: Buildings and Community Systems (cont.)

SUBPROGRAMS	(in millions) FY 82 Appropriation	FY 83 Reconciliation	FY 83 Proposed
E) Technology and Consumer Products	10.6	11.6	16.2
Projects to include:			
1) Research and development support for new heating and cooling (e.g. heat pumps), lighting, and commercial appliance systems.			
2) Evaluation and testing of new energy-conserving technologies brought into the market.			
F) Appliance Standards	1.6	+	4.0
Projects to include:			
1) Development of test procedures for FTC appliance labeling.			
* 2) Development of appliance efficiency standards.			
G) Analysis and Technology Transfer	1.0	2.1	4.0
Projects to include:			
* 1) Evaluation of the performance of BCS programs.			
* 2) Development of a data and information system to support the BCS programs.			
H) Federal Energy Management Program	.5	0.0	2.0
Projects to include:			
1) Updating of guidelines to improve the energy efficiency of federal operations with backing from research in the various conservation programs.			
2) Dissemination of energy information to all federal agencies.			
I) Municipal Waste/Urban Waste	4.8	6.9	7.0
Projects to include:			
1) Research, development, and demonstration of energy from waste technologies.			
* 2) Integration of energy recovery and materials recovery (e.g. recycling) systems to reduce energy waste.			
J) Program Direction	3.4	6.7	3.4
SUBTOTAL	47.7	56.2	78.8
		+ 25.6	
TOTAL	47.7	81.8	78.8

Department of Energy

PROGRAM: Industrial Energy Conservation

(in millions)

SUBPROGRAMS	FY 82 Appropriation	FY 83 Reconciliation	FY 83 Proposed
A) Waste Energy Reduction	11.9	13.1	15.0
Projects to include:			
Research and development support for long term waste energy reduction technologies and systems.			
B) Industrial Process Efficiency	7.7	8.5	15.0
Projects to include:			
Research and development spport for long term process efficiency technologies.			
C) Industrial Cogeneration	2.3	5.5	5.0
Projects to include:			
Research and development support for long term cogeneration technologies.			
D) Implementation and Deployment	4.8	4.2	5.5
Projects to include:			
1) Support for the six Energy Analysis and Diagnostic Centers.			
* 2) Analysis of the market potential in industry for the new energy-conserving technologies now being developed.			
* 3) Dissemination of information on new processes and technologies through technical reports and seminars.			
* 4) Analysis of the effectiveness of the Industrial Energy Conservation program.			
E) Program Direction	2.1	2.6	2.2
TOTAL	28.8	33.9	42.7

Department of Energy

PROGRAM: Transportation Energy Conservation

(in millions)

SUBPROGRAMS	FY 82 Appropriation	FY 83 Reconciliation	FY 83 Proposed
A) Vehicle Propulsion	33.5	36.7	15.0
Projects to include:			
* 1) A cooperative research program with auto manufacturers on direct injection stratified charge and diesel engines, advanced-transmissions, lubricants, and tires.			
2) Basic research on advanced Stirling and Brayton engines.			
B) Electric and Hybrid Vehicle R&D	18.8	20.7	10.0
Projects to include:			
Research on advanced battery systems			
C) Transportation Systems Utilization	.1	3.5	8.0
Projects to include:			
* 1) Outreach on Low Cost/No Cost motor vehicle conservation activities.			
* 2) Dissemination of information on the potential for consumers to increase the gas mileage of new car fleets (e.g., the Gas Mileage Guide).			
* 3) Research support and outreach for new technologies designed to increase the energy efficiences of rail, marine, air, and pipeline transportation.			
D) Alternative Fuels Utilization	4.0	5.5	8.0
Projects to include:			
* Development of methanol- and ethanol-propelled vehicles.			
E) Program Direction	1.7	1.7	2.0
TOTAL	58.9	68.0	43.0

Department of Energy

PROGRAM: State and Local

(in millions)

SUBPROGRAMS	FY 82 Appropriation	FY 83 Reconciliation	FY 83 Proposed
A) Schools and Hospitals Grants Program	48.0		96.0
Projects to include:			
Retrofit of about 2000 school or hospital buildings.			
B) Weatherization Assistance Program	144.0		234.0
Projects to include:			
Retrofit of about 200,000 low income homes.		354.5	
C) State Energy Conservation Grants	24.0		30.0
Projects to include:			
1) Support for state energy offices.			
2) State development of energy management programs.			
D) Emergency Energy Conservation Planning	1.9		10.0
E) Energy Extension Service	9.6	15.8	15.0
F) Program Direction	6.7	-	8.0
TOTAL	234.2	370.3	393.0

Department of Energy

PROGRAM: Multisector

(in millions)

SUBPROGRAMS	FY 82 Appropriation	FY 83 Reconciliation	FY 83 Proposed
A) Appropriate Technology	2.9	5.3	5.0
Projects to include:			
Grants to make use of community-based, energy-related technologies that conserve non-renewable resources.			
B) Invention Program	5.2	5.7	4.0
Projects to include:			
Support to inventors for energy-conserving inventions.			
C) Energy Conversion and Utilization Technology	7.8	9.7	8.0
Projects to include:			
Support for long term research and development for increasing energy productivity.			
D) Personnel Resources	.6	.4	.6
TOTAL	16.5	21.1	17.6

Department of Housing and Urban Development

PROGRAM: Solar Energy and Energy Conservation Bank

	(in mi[illegible]s) FY 82 Appropri-ation	FY 83 Reconcil-ation	FY 83 Proposed
Stimulus to retrofit 42,000 homes, reducing energy use by an average of 25 percent and saving an estimated 4.5 million barrels of oil equivalent over the life of these investments.	23.0	50.0	50.0

* Indicates an activity that should be implemented but presently does not exist. (Such an activity may either be completely new or it may have previously existed but has subsequently been eliminated).

BIOGRAPHY

Deborah Lynn Bleviss is associate director of the Federation of American Scientists, and a member of the Board of Directors of the Energy Conservation Coalition. She has been with the Federation for two years, serving as its special assistant for energy. Prior to that, she served as a staff scientist with the Massachusetts Audubon Society where she co-authored a book on energy which is due out shortly--The Energy Sayer's Handbook for Town and City People, to be published by Rodale Press.

Mr. FUQUA. MR. BULLOCK?

Mr. BULLOCK. Mr. Chairman, my full statement has previously been submitted and I would appreciate your making that a part of the record.

Mr. FUQUA. Without objection, we will make that a part of the record. I would also like, following my opening statement, to insert into the record a statement by Congressman McCurdy. (See p. 74.) Please proceed and summarize if you wish.

STATEMENT OF ELLIS BULLOCK, VICE PRESIDENT, AMERICAN INSTITUTE OF ARCHITECTS

Mr. BULLOCK. Mr. Chairman and committee members, my name is Ellis Bullock, Jr., FAIA I am president of Bullock Associates, a medium-sized architectural firm in Pensacola, Fla. About 90 percent of my practice involves the design and construction of facilities for several Federal agencies, State and local governments, and utility companies. My practice is centered in Florida, Alabama, and Mississippi.

Today I represent the American Institute of Architects, the national organization for American architects. This year, I am a vice president of the institute. I am also the chairman of the AIA's Energy in Architecture Committee.

The AIA's membership is about 37,000 architects or about 10,000 member firms. Most architects are small businessmen. About 75 percent of our member firms contain nine or fewer persons.

THE AIA'S COMMITMENT TO ENERGY CONSERVATION

I would like for you to know that the AIA has a longstanding commitment to increase the energy efficiency of our Nation's building stock. In the mid-1970's, we pioneered the energy performance approach to the designing of new buildings.

We also believe that energy-efficient buildings are one of the largest and most cost-effective sources of energy over the next decade. The AIA believes that Federal policies must augment the private sector's attempts to increase efficiency of the Nation's buildings.

The AIA has taken on the responsibility of teaching its members how to design more energy-efficient buildings. Last year, we embarked on our own energy education program entitled "Energy in Architecture." The program will sharpen the design skills of our

members. By the end of 1983 we hope to reach 8,000 member firms in this program.

In 1981, we have invested over $1 million of our own money out of an annual budget of $12 million.

I am here to express the AIA's concern over the Department of Energy's fiscal year 1983 budget for conservation and solar programs and to stress the need for continued Federal involvement in buildings research programs. We will also propose an integrated research program, called the building energy research program.

First of all, the AIA finds the fiscal year 1983 budget for conservation and solar programs ignores the important contribution that energy-efficient buildings make to the Nation's economic health.

DOE FISCAL YEAR 1983 OVERLOOKS POTENTIAL FOR ENERGY EFFICIENCY

At this time, the AIA will not give you a detailed budget for the DOE buildings or the solar programs. However, we would like to see DOE be required to spend its appropriated funds and complete its ongoing programs. Therefore, we suggest a rollover provision so that the amount that the DOE does not spend in fiscal year 1982 or other fiscal years will be rolled over from year to year so that the programs are completed or the money is spent.

As you are well aware, DOE's fiscal year 1983 budget will abruptly terminate many initiatives that are important to the design of even more energy-efficient buildings. We would like to see the results of these projects captured in useful formats before the information is lost forever. We think it is a waste of the taxpayers dollars, not to bring ongoing research projects to some proper conclusion.

In addition, DOE's current plans to package research results from existing projects in scientific technical reports will be of little use to the average architect or engineer involved in the design of buildings.

The AIA believes that DOE should continue to do applied research on commercial buildings so that our members can continue to improve their energy design skills. The results of using energy conservation technology and passive design strategies can only be readily understood by monitoring the energy performance of the actual buildings.

COST AND PERFORMANCE DATA

Architects and engineers must have cost and performance data on buildings' actual operation in order to evaluate the success or failure of a particular energy strategy. While many building owners are willing to have their buildings instrumented for data collection, they are not willing to bear the incremental cost. Therefore, the funding is needed for additional cost of installation of the equipment and collection and analysis of data for a greater variety of building types and in more diverse climatic regions of our country.

ENERGY DESIGN TOOLS

Architects also need energy design tools that are compatible with the architectural practice. Up till now the design tool development has lagged behind because DOE has emphasized the development of large computer programs. Using these programs is very expensive and they are only available to a very few, large design firms. In addition, many of the existing programs have been developed for a single use and cannot model tradeoffs between heating, cooling, and lighting requirements.

The majority of architectural firms need simple-to-use, inexpensive design tools in the form of manuals, graphs, charts, and programs for hand-held calculators and microcomputers.

DAYLICHTING

Lighting is a major energy user in commercial buildings; often accounting for as much as 30 percent of the building's energy demand.

In order to deliver lighting at a lower energy cost, basic research on more sophisticated systems needs to be initiated.

Daylighting can be a help or a hindrance. The Sun can contribute light and heat to a building but it may also increase its air-conditioning load.

RETROFIT OF EXISTING BUILDINGS

A more systematic understanding of the ways to increase the retrofit of existing commercial buildings is needed. Retrofit in the commercial sector is one of the most difficult and complex tasks to undertake for the architect and the engineer because of the variety of building types and owners.

Much of DOE's previous work has been oriented toward the BEPS and new buildings design and it has caused a lag in energy audit techniques and retrofit knowledge.

DOE'S PASSIVE COMMERCIAL BUILDINGS PROGRAM

AIA would like to stress that DOE has made a significant contribution to the understanding of energy use in buildings through such programs as the passive commercial buildings program. This has been especially useful to the design community. It has spawned a great deal of information on passive commercial design, which has resulted from the data collection and analysis on 20 differently instrumented commercial buildings.

The AIA would like to point out the high interest rates are affecting energy choices made by commercial building clients. In spite of high energy prices, many clients are selecting projects that contain energy features that have a pay back of only 1 to 2 years because they cannot afford to finance the energy conservation solutions with longer payback periods because of their higher initial construction costs. This, of course, always means high operating costs and more energy consumption over the lifetime of the building.

Some would like to have us us believe that the price of energy will bring about energy-efficient buildings, thus eliminating the

need for Federal involvement in building and energy research. While the AIA believes that price has a significant influence, we do not believe that price alone is a sufficient initiative because for building owners and investors, energy and economic choices do not always coincide.

First, the price of energy is rather rarely a major factor when a client commissions a building. Rather the structure is designed to meet the client's purpose, location and economic criteria rather than how much it will cost to operate.

Generally, if an owner is paying for the energy bill he is interested in lower operating costs than if the tenant is paying the energy bill.

BUILDING ENERGY RESEACH PROGRAM

The research on buildings and their components has been spread over the conservation program as well as the active and passive solar programs at DOE. This approach has provided a significant quality of information, but the nonintegrated operation of the three programs has led to duplication, overlap, and omissions.

To remedy this situation, a coalition of members of the building industry and public interest groups are now developing a program alternative called the building energy research program, an integrated federal research program based on the needs of the building industry and building occupants. It proposes that the research program should focus on the buildings as units in the community context.

The program is based on several important premises:

One, that buildings are dynamic energy-using systems. Therefore research should be focused on ways of improving the energy efficiency of the building as a total system.

Two, the research program would be based on the characteristics of the building stock and would recognize that residential, commercial and multiple-family buildings have different design and construction techniques and different occupancy patterns.

Three, the research priorities would be based on specific needs of user groups of building information, including architects, engineers, homebuilders, building owners, and building occupants.

Four, the priorities should be developed in close cooperation with these end-users.

Five, the research program recognizes the inherent fragmentation of the entire building industry.

Six, the research program should contain both basic and applied activities.

Seven, residential and commercial retrofit would be given special emphasis because of the tremendous potential to improve the efficiency of these buildings.

Briefly, to review only three of these points: Unlike the automobile industry, which has about four major manufacturers, the building industry is made up of many small businessmen and many product manufacturers which prevents groups from supplying vast amounts of capital which is needed to conduct an integrated buildings energy research program. This research program that we pro-

pose would recognize that it is appropriate for the Federal Government to provide the focal point for a buildings research program.

The building energy research program also recognizes that an effective research program must meet the research priorities of architects, engineers, homebuilders, homeowners, and building occupants. At DOE, end-users have frequently been shut out at the planning process. Therefore, the program would propose the use of a consultation method that would assist the DOE in understanding the needs of the building community.

The building energy technology program would give special emphasis to retrofit of existing buildings. Of the buildings that exist today, 80 percent will exist in the year 2000.

The simple reduction in lighting levels and infiltration rates and improvements in mechanical systems can reduce commercial energy consumption by as much as 30 percent.

SUMMARY

In summary, over 37 percent of the Nation's energy consumption is used by the building sector. Therefore, it is appropriate for the Federal Government to concentrate on an appropriate level of effort to increase its energy efficiency.

We are told that the current softness in the oil market is only a temporary phenomena. Therefore, we must continue planning for a future of decreasing energy supply and ever-increasing energy prices by increasing our investment in energy-efficient buildings.

Therefore, we hope that you will seriously consider the AIA's proposal for continued funding of applied research needs of the commercial building community as well as give serious consideration to the building energy research program when it is submitted to you later on this month.

Thank you.

[The prepared statement of Mr. Bullock follows:]

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FISCAL YEAR 1983 AUTHORIZATION FOR THE DEPARTMENT OF ENERGY'S CONSERVATION RESEARCH AND DEVELOPMENT PROGRAMS

A STATEMENT BY
ELLIS BULLOCK, JR., FAIA
VICE PRESIDENT, THE AMERICAN INSTITUTE OF ARCHITECTS
CHAIRMAN, ENERGY IN ARCHITECTURE COMMITTEE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES
MARCH 11, 1982

Introduction

Good Afternoon, My name is Ellis Bullock, Jr., FAIA, I am the President of Bullock Associates, a medium sized firm in Pensacola, Florida. About 90 percent of my firm's activities involves the design and construction of facilities for several federal agencies, state and local governments and utility companies. My practice is centered in Florida and Mississippi.

Today I represent The American Institute of Architects, the national organization for American Architects. This year, I am a Vice President of the Institute. I am also the Chairman of the "Energy in Architecture" Committee.

The AIA's membership is about 37,000 architects or about 10,000 firms. Most architects are small businessmen. Only two and a half percent of AIA's member firms contain 50 or more employees, while over 75 percent of our members' firms contain nine or fewer employees.

The AIA's Commitment to Energy Efficiency

I would like you to know that the AIA has a long-standing commitment to increase the energy efficiency of our nation's building stock. In the mid 1970's, we pioneered the energy performance approach to designing new buildings.

We also believe that energy efficient buildings are one of the largest and most cost-effective sources of energy over the next decade. The AIA believes that federal policies must augment the private sector's attempts to increase the efficiency of the nation's buildings.

The AIA has taken on the responsibility of teaching its members how to design more energy efficient buildings. Last year, we embarked on our energy education program, called: "Energy in Architecture." This program will sharpen the design skills of our members. We decided to offer these seminars because many architects obtained their degrees when energy was not part of architectural curricula. By the end of 1983, we hope to reach 8,000 member firms with this program.

I am here to express the AIA's concern over the Department of Energy's FY 83 budget for Conservation and Solar programs and to stress the need for continued federal involvement in buildings energy research. We also will outline an integrated research program, called the "Buildings Energy Research Technology" Program.

The DOE FY 1983 Budget Ignores the Potential of the Building Industry

First of all, the AIA finds the FY 1983 budget for Conservation and Solar programs to be unacceptable and inappropriate. The dramatic cuts in conservation programs and proposed elimination of the active and passive solar programs demonstrate lack of understanding of

the building industry by this administration. The budget also ignores the large investment that the nation makes in buildings as well as the contribution energy efficient buildings can make to the nation's economic health and defense posture.

As you are well aware, the DOE FY 1983 budget would abruptly terminate many initiatives that are critically important to the design community. In addition, we fear that the results from many projects will be lost forever. We also see the list of cancelled projects growing and major procurements being cancelled because of political pressure from the Office of Management and Budget (OMB).

At this time, the AIA will not give you a detailed budget for the buildings and solar programs. When the "Building Energy Research Technology" Program is submitted later this month, we will submit our recommendations. However, we believe that DOE should be required to spend its appropriations, rather than be allowed to continue its present policy of deferrals and other stalling tactics. We also would like to see DOE prevented from returning its funds. Therefore,we are suggesting a rollover provision so that the amount that DOE does not spend in FY 1982 or other fiscal years must be rolled over from fiscal year to fiscal year until it is spent.

DOE Research Efforts Lack Proper Conclusion

At the program level, we would like to see ongoing research projects prevented from being terminated in midstream. It is a waste of taxpayers' dollars not to bring ongoing projects to some proper con-

clusion. At the very minimum, those projects scheduled for termination should have a provision that would require DOE to turn the data over to appropriate private sector groups, so that some type of information dissemination could occur. We would also like to see the DOE staff prepare a list of all the projects terminated since January, 1981. This list should contain a rate of completion and the source and type of data contained in each project. This list should be widely disseminated. Then legitimate private sector groups, such as trade and professional associations, should be given the option of obtaining the data for analysis and dissemination. DOE should assist this process by providing staff assistance and reproduction costs.

In addition, priority and funding should be given to the continued analysis of completed DOE projects. For example, a list of DOE projects and publications compiled by the National Academy of Sciences reveals that DOE has sponsored some 53 projects on commercial buildings. Yet, we have only a very vague idea of how all that information fits together because these projects were conducted within a non-integrated, non-systematic research framework. There is no doubt the design community needs a vehicle to analyze this massive amount of information so it can be integrated into existing information delivery systems, already familiar to architects, engineers, and homebuilders.

The AIA's Research Priorities

Before I detail the AIA's recommendations for a continued federal role

in energy research for commercial buildings, I would like you to understand that most design professionals do not really understand how buildings use energy. It is easier to understand how to use a specific piece of technology than it is to understand how a building operates as a dynamic energy-using system. For example, when an architect decides to design an office building in curvilinear form rather than a rectangular shape, we know that the curvilinear shape will expose much more office space to daylighting but we can't be terribly sure how that change affects the building's heating and cooling requirements or in what climatic conditions it would provide a positive trade off in terms of energy savings.

Therefore, we are asking for continued federal involvement in those projects that will yield data which will enable design professionals to produce better buildings and then convince their clients that energy efficient buildings are a good investment. Those needs include:

Monitoring of Occupied Buildings

The results of using energy conserving technologies and passive design strategies can only be really understood by monitoring the energy performance of actual buildings. Unlike automobiles, buildings cannot be put on a test track. Architects and engineers must have cost and performance data on a building's actual operation in order to evaluate the success or failure of particular energy strategies. Cost and performance data on buildings are also needed to convince clients that energy options are a good investment.

While many building owners are willing to have their building instrumented for data collection, they are not willing to bear the incremental cost. Therefore, funding is needed for the additional cost of installing that equipment and the collection and analysis of the data for a greater variety of building types in more climatic regions.

In addition, existing cost and performance data should be collected and placed in a meaningful, uniform format. This data should be stored in an information system that is not dependent on federal funding, so it can be a dependable source of data for building designers.

We would also like to stress that any new effort to disseminate DOE data must recognize its ultimate users, whether they be homebuilders architects, or consumers. The building community must have information in a meaningful format. If DOE should undertake any further information dissemination, these activities should occur only after consultion with specific user groups or their representatives.

Design Tools

All the information and research results are of little use to the commercial building community if it doesn't help them to design more energy efficient buildings in approximately the same of amount of design time. Therefore, architects need energy design tools that are compatible with architectural practice.

Up to now, design tool development has lagged behind because DOE

has emphasized large computer programs, such as DOE-2. These programs are very expensive and can only be easily used by large design firms, which are a very small minority of the architectural and engineering profession. In addition, many of the existing computer design tools have been developed for a single use, such as lighting, and cannot model trade offs between heating, cooling and lighting strategies.

Some proprietary tools are now available. However, proprietary knowledge must always be paid for and does not facilitate innovation and adaption by the design and engineering community.

A majority of architectural and engineering firms would benefit from the development of basic, simple to use, and inexpensive design tools in the form of design manuals, graphs, charts, and programs for hand-held calculators.

Climatic Data

A building's energy demand is influenced tremendously both by the general climatic region where it exists as well as by the very immediate climate surrounding the building. For example, the wind velocity may differ dramatically on each side of the building. Architects must be able to adapt the building's energy design to fit these climate conditions. Therefore, the building designers must have adequate climate data at the regional and microclimate levels. To understand microclimate impact, incremental funding is needed for the instrumentation of actual buildings.

Lighting

Lighting is a major energy user in commercial buildings; often accounting for as much as 30 percent of the building's energy demand. Given that many illumination standards are quite old, the need exists to determine what are the appropriate levels of lighting. Designers and engineers both believe that illumination levels can be reduced and the use of task lighting be increased, but they do not know how much lighting humans actually require. This requires laboratory testing in order to define optimum lighting standards and their effects on other energy functions.

In order to deliver lighting at a lower energy cost, basic research on more sophisticated control systems needs to be initiated. It appears possible that elements from the electronic and computer industries may have applications for lighting systems.

Daylighting can be a help or a hindrance. Light from the sun can contribute lighting and heat to a building or increase its air conditioning load. Therefore, better control devices are needed to bring in optimum amounts of heat and light into buildings. Some work has been started on design and control systems but cost and performance data is needed to increase their use.

Air Quality

The emissions from building products, when combined with reduced numbers of air changes in energy efficient buildings, raise the issue of indoor air quality. Given the possible health issues and cost

implications, both the building industry and building occupants need continued assessment of the possible health effects of indoor air contaminants on human health. This analysis should be followed by the development of easy-to-use and inexpensive detection and monitoring devices for on-site use in buildings.

It is evident that the market will not produce this type of information, due to its lack of potential profitability. None the less, for human health, it is imperative the assessment work that has been started at DOE and EPA should be continued, not eliminated.

Advanced Building Materials and Components

Basic research is needed to develop advanced glazing materials and building shell materials as well as thermal storage materials for commercial buildings. Preliminary work on a variety of these materials indicate their energy saving potential. Therefore, additional refinement is needed before building product manufacturers will invest their product development funds.

Development of basic energy conversion technology is also required so that building owners can anticipate how to convert existing mechanical systems to alternate fuel sources, such as photovoltaics,

Commercial Building Retrofit

A more systematic understanding of the ways to increase the retrofit of commercial buildings is needed. Retrofit in the commercial

sector is one of the most difficult and complex tasks to undertake because of the variety of building types and owners. Much of DOE's work was oriented towards BEPS and new buildings design which has caused energy audit techniques and retrofit knowledge to lag behind. The most critical needs are for more sophisticated controls and retrofit equipment as well as retrofit cost data and post retrofit performance data.

Energy Prices are not a Sufficient Incentive

The Reagan Administration would like us to believe the price of energy will bring about energy efficient buildings, thus eliminating the need for federal involvement in buildings and energy research. While the AIA believes that price has a significant influence, we do not believe that price alone is sufficient incentive because, for building owners and investors, energy and economic choices do not always coincide.

First, the price of energy is rarely a major factor when a client commissions a building. Rather, a structure is designed to meet the client's purpose, location and economic criteria. Some are built for owner occupancy, some for leasing and others for speculation. These ownership categories affect the willingness of a building owner to invest in energy efficiency. If the owner is paying the energy bill, he is more interested in lower operating costs than if a tenant pays the energy bill.

In addition, price alone is probably not a sufficient catalyst to bring new technologies into the market place because new building products, equipment and design techniques must be accepted by the building design and construction community. A recent GAO study entitled "Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs," pointed out that homebuilders are reluctant to adopt to new materials and technologies. The AIA's own experience with its "Energy in Architecture" seminars indicate that common energy concepts may not be as well diffused as initially expected.

Furthermore, even when an architect knows how to design an energy efficient building, he must be able to sell the building to his clients. Particularly in commercial buildings, design firms must be able to predict the cost and energy performance of design strategies.

High Interest Rates Affect Energy Choices

The AIA would like to point out that high interest rates are affecting the energy choices made by commercial building clients. In spite of the high energy prices, many clients are either postponing projects or selecting projects that contain energy features that have a payback of only 1-2 years. They are making these choices because they cannot afford to finance energy conservation solutions with longer payback periods because of their higher initial construction costs. This economic decision by clients almost always means higher operating costs over the lifetime of the building.

The Building Energy Research Technology Program

The research on buildings and their components has been spread out over the conservation programs as well as the active and passive solar programs at DOE. This approach has provided a significant quantity of information, but has not produced a systematic body of information on improving the energy efficiency of the built environment. Rather, the non-integrated operation of the three programs has led to duplication, overlap and omissions.

To remedy this situation, a coalition of members of the building industry and public interest groups are now developing a program alternative called the "Building Energy Research Technology Program," which is an integrated federal research program based on the needs of building industry and building occupants. It proposes that the research program should focus on the building as a unit in its community context.

The program is based on several important premises:

1. Buildings are dynamic energy-using systems. Therefore research should be focused on ways of improving the efficiency of the building as an integrated system. This integrated approach departs from the current research programs which have tended to focus on individual technologies and building components.
2. The research program would be based on the characteristics of the building stock and would recognize that residential, commercial and multi-family buildings have different design

and construction techniques and occupancy patterns. These characteristics determine the amount of energy a building uses and therefore, research should be structured in recognition of these differences.

3. The research priorities would be based on the specific needs of each end user group of building information, including architects, engineers, homebuilders, building owners and building occupants.
4. The priorities would develop in close cooperation with these end users. All research projects would produce appropriate formation for the users groups.
5. The research program would recognize the inherent fragmentation of the entire building industry, and the special problem that presents for its research capacity and information transfer.
6. The research program would contain both basic and applied activities.
7. Residential and commercial retrofit would be given special emphasis because of the tremendous potential to improve the efficiency of the existing building stock.

Today the AIA will only discuss three of these points. However, the entire program will be explained in detail when the coalition submits its plan later this month.

Unlike the automobile industry, which has about four major manufacturers, the building industry is made up of small businessmen and many product manufacturers. The "Building Energy Research Technology" program recognizes that this inherent fragmentation prevents the building industry from supplying the vast amounts of capital that would be needed to conduct an integrated buildings energy research program. This research program also recognizes that it is appropriate for the federal government to provide the focal point for a buildings research program, just as it does for the nuclear industry.

The building industry differs from the auto industry in another way. Whereas it takes about eight years for new auto technology to be incorporated into product lines, innovation and use of new materials takes much longer in the building industry. For example, it took about 15 years for the building industry to accept the use of drywall. The Building Energy Research Technology Program will address this characteristic by recommending that all DOE research projects contain information dissemination components designed to meet the needs of end user groups. The program recognizes that the research projects will be more effective if research results are delivered to information users in appropriate formats and are delivered through existing information channels.

The Building Energy Research Technology Program also recognizes that an effective research program must meet the research

priorities of the building sector end user including: architects, engineers, homebuilders, homeowners and building occupants. At DOE, end users have been frequently shut out at the planning process for programs. Therefore, the Building Energy Research Technology Program will propose a consultant method that would assist DOE in meeting the research needs of the building community. We believe that this recognition of the building sector's priorities and end user needs will create an atmosphere that will encourage cost sharing between the building industry and the government.

The Building Energy Research and Technology Program will give special emphasis to retrofit of existing buildings. This emphasis is critical because buildings last such a long time. Eightly percent of the buildings that exist today will still be here in the year 2000.

We also believe that retrofit is important because of the significant reductions in energy use that can be obtained through effective retrofit strategies. Reduction in lighting levels and infiltration rates and improvements in mechanical systems can reduce commercial energy consumption by as much as 30 percent.

Summary

Over 37 percent of the nation's energy consumption is used by the building sector. Therefore, it is appropriate for the federal

government to concentrate on an appropriate level of effort to increase its energy efficiency.

Reducing use of conventional fuels by the buildings sector will bring economic benefits to the nation as a whole and to homeowners and building owners. A more comprehensive and coordinated approach to building energy research can offer progress toward this end.

The current softness in the oil market is only a temporary phenomenon. Therefore, we must continue planning for a future of decreasing energy supply and ever increasing energy prices by increasing investment in energy efficient buildings.

Therefore, we hope that you will seriously consider the AIA's proposal for continued funding for applied research needs for the commercial building community, as well as give serious consideration to the Building Energy Research Technology Program when it is submitted to you later this month.

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Background

Ellis Bullock, Jr., FAIA

Ellis Bullock, Jr., FAIA, is a Vice President of The American Institute of Architects. He is also the Chairman of the AIA's "Energy in Architecture" Committee. In addition, he represents Florida and the Caribbean on the AIA's Board of Directors.

Mr. Bullock is also president of his own firm, Bullock Associates in Pensacola, Florida. His firm is involved in the design and construction of facilities for several federal agencies, state and local governments and election utilities.

Mr. Bullock has been an architect for over 25 years. He received his architecture degree from Tulane University in 1954. He was nominated to be a Fellow of The American Institute of Architects (FAIA) in 1981. He also is frequently a guest lecturer at the school of architecture at Auburn University.

Mr. FUQUA. Thank you very much, Mr. Bullock. We appreciate your testimony.

Our next witness will be Mr. Clair Ames, president of Ames Building Corp. of Evansdale, Iowa. Mr. Ames we are pleased to have you here today.

STATEMENT OF CLAIR AMES, PRESIDENT, AMES BUILDING CORP., EVANSDALE, IOWA

Mr. AMES. Thank you, Mr. Chairman.

I would like to thank the Subcommittee on Energy Development and Applications for the opportunity to express my personal views on the past, present, and future involvement of the Federal Government in the energy related fields.

My name is Clair Ames and I am a new housing contractor building passive solar homes. I started in the construction field 13 years ago, and started my own construction company 6 years ago.

We built conventional well-insulated homes for several years with 6-inch exterior walls, 10 inches of insulation in the attic, and installing casement windows in our homes to reduce infiltration.

Early in 1979, realizing what the effect of the decontrol of natural gas prices would do to the cost of heating a home, I decided that there must be an alternative to the conventional homes we were building.

I started attending solar seminars and reading as much as I could find on building new solar homes. I found that the active systems available were just not suitable for new construction. The active systems would provide heat only while the Sun was shining, but made no provisions to adequately store the heat during the day for nighttime use. Passive solar seemed the most logical way to incorporate solar heat into a new home.

The concept of designing a home to heat itself versus adding something onto a conventional home fascinated me. Due to the lack of designs for well-planned passive solar homes and the lack of architects experienced in this field, I decided to do the design work myself.

During my research into passive solar I attended a seminar called the Iowa Solar Operational Results Conference sponsored by the Iowa State Solar Office, the Iowa Energy Policy Council, and the Community Action Research Group. I attended several others, but this one was the most informative of them. The general public was also very interested in learning about solar and energy conservation in general.

In the summer of 1979, we started construction of our first passive solar home. Market acceptance at first was slow but there was a lot of interest in the general concept. After building two homes, incorporating direct gain design and then building two homes, incorporating a combination of direct gain and trombe wall, I came to the conclusion that the combination of the two was the best. This was also the same time that the U.S. Department of Energy was preparing a 436-page passive solar design manual recommending the same thing.

This new design features a super insulated shell with 10-inch exterior walls and 16 inches of insulation in the attic. I designed the

floor plan so that all of the major rooms had a southern exposure and eliminated the need for any windows on the east, west, or north sides of the home. The south wall of the home had a continuous wall of glass with a 12-inch poured concrete wall placed directly behind the fixed patio glass units, with opening in the trombe wall for operable windows. This gave the appearance of the interior of a conventional home, except you could heat these homes for less than $50 per year. They also featured wall-to-wall carpeting unlike most previously built passive solar homes.

The definition of the DOE, courtesy of the World Book Encyclopedia, is:

> An executive department of the U.S. Government that works to meet the Nation's energy needs. The Department develops and coordinates national energy policies and programs. It promotes conservation of fuel and electricity. It also conducts research to develop new energy sources and more efficient ways to use present supplies.

It is my opinion that this branch of the Government, with the thought of a $100 billion deficit in mind, should be terminated immediately, and not allowed to exist with a substantially reduced budget. This branch of the Government, like the Department of Education, and the Department of Housing and Urban Development have served their usefulness. The only thing they accomplish now, is to give a lot of bureaucrats jobs, spend our taxpayers money and cause the businessman an excessive amount of paperwork and hassle.

Several of these agencies are currently producing as much paperwork as possible to make it seem that the Government cannot function without them. If I was employed with one of these agencies, I would probably be doing the same thing trying to protect my job. But, it is time we all wake up to the impending financial catastrophe facing this country if the course of this Government is not drastically changed, and the sooner the better.

The Federal Government should heed this administration's policy for energy which is based on the basic principles of marketplace supply and demand. By freeing the energy market to allocate goods and services efficiently, solar energy, along with other energy alternatives, will be developed and utilized at a rate consistent with its economic potential.

This is already happening in the passive solar field due to the deregulation of natural gas. It has suddenly become economically feasible to build a passive solar home instead of a conventional home.

If the Federal Government had not imposed regulations on the cost of natural gas in the first place, we would not have needed the Department of Energy to help speed the development of technology in the solar field. The market would have demanded solar homes a lot sooner and more gradual, so that homebuilders would have had more time to incorporate these changes into their designs. This theory would also apply to almost any other of the energy related fields. If it is economically feasible and practical, you can bet that someone in the private sector is working on it. The Federal Government needs to play a quiet role in this by giving tax breaks or deductions only when absolutely necessary.

This country was made great by inventors such as Henry Ford, Thomas Edison, Benjamin Franklin, Eli Whitney, and Alexander Graham Bell, just to name a few. These people did not wait for a grant from the Government or a tax deduction before they proceeded with their inventions. They took it upon themselves to perfect and market their inventions in the great American tradition.

The biggest problem that this country faces is not the economy, an oil embargo, or the threat of nuclear war, it is the attitude of the everyday worker who sees a substantial portion of his paycheck being spent recklessly by our Government. He sees his neighbor next door who is living on unemployment, making as much money after taxes as he does. His teenage son is unable to get a job because the employer cannot afford to pay the inexperienced boy the minimum hourly wage. It is the 45,000 regulations on one McDonald's hamburger which adds 10 cents to the cost of every hamburger. It is the income tax forms that the average individual cannot fill out. It is the regulations that increase the cost of an average home thousands of dollars. They are regulations that require countless gadgets to be installed on new cars which the owners have to pay the local mechanic to take off. Above all, it is the 17-percent-plus interest rates keeping a young couple, both working, from buying a new home, when a person in a low-income bracket can get a federally subsidized loan on a new home. Why should the average American increase his productivity when he is penalized every time he turns around and rewarded for not doing well.

I have always maintained that there is no such thing as underprivileged people, only motivated and unmotivated people.

This country used to be a great leader in technology in this world, but has been slipping in previous years due to the interference of State and Federal Governments in the private sector. This, I realize, was not intentional or a Communist plot to ruin the Nation's productivity. It happened gradually with good intentions on the part of the lawmakers. But it boils down to one thing. A free capitalistic society gives an individual the opportunity to set a goal in life as high as he wants to and still have the possibility to reach that goal. No other form of government can possibly do this. Now is the time for the Federal and State governments to give us Americans back this basic human right.

Please keep in mind when preparing the 1983 budget what John F. Kennedy said in his inaugural address 21 years ago: "Ask not what your country can do for you; ask what you can do for your country."

I will leave you today with this thought. At the subcommittee hearing in Des Moines, Iowa, held several weeks ago, Mr. Tom Harkin brought up the fact that he thought the Federal Government should get involved with the energy applications in this country similar to the Government's involvement in the REC program of years past. His reasoning was that if the Government had not passed this piece of legislation, we would probably still have farms without electricity. I look at it differently. If the farms did not have electrical energy available, do you suppose that wind generators, photovoltaics, passive solar, biomass energy, and alcohol fuels would be advanced far beyond today's level if the Government had chosen not to get involved in the energy market? Thank you.

Mr. FUQUA. Thank you very much, Mr. Ames. Our final witness will be Mr. Ralph Johnson, president of the Research Foundation, National Association of Home Builders.

Mr. Johnson, we are pleased to have you with us.

STATEMENT OF RALPH J. JOHNSON, PRESIDENT, RESEARCH FOUNDATION, NATIONAL ASSOCIATION OF HOME BUILDERS

Mr. JOHNSON. Mr. Chairman and members of the subcommittee. I think after listening to Mr. Ames I should recommend to the homebuilding industry that they go into the hamburger business if 45,000 regulations only increases the price 10 cents.

Our regulations add at least $10,000 to the price of a new home.

My name is Ralph Johnson and I am president of the NAHB Research Foundation, a not-for-profit subsidiary corporation of the National Association of Home Builders.

Today I am testifying on behalf of the research foundation and the more than 116,000 members of NAHB who, in normal times, employ over 3 million workers. NAHB is the trade association of the Nation's homebuilding industry. With me today is Joe McGuire, NAHB's director of regulatory affairs.

Mr. Chairman, thank you for the opportunity to appear before the subcommittee today to present our views on DOE's conservation and solar programs for fiscal year 1983 aimed at the building sector. I have a complete statement which has been given to this committee which I would like incorporated in full into the record.

I would like to highlight a few of the remarks, if I may.

Before I comment on the DOE proposals for fiscal year 1983 I would like to present some facts on the current state of the homebuilding industry.

To put it bluntly, the homebuilding industry has just finished its worst year on record. On top of that, NAHB forecasts, that for 1982, starts will be at the lowest level since 1946. Many members are experiencing severe financial difficulty, or they have gone out of business.

In addition, January was the sixth straight month in which the seasonally adjusted housing starts rates was below 1 million. Building permits in January were 31 percent below the January 1981 level. Total housing starts for 1981, 1.1 million, were down 16 percent from 1980, which, in turn was 25 percent below 1979, which was 14 percent below 1978. That kind of disaster we really cannot use.

Unemployment in construction in February was 18.1 percent, more than twice as high as the overall unemployment rate. In my own 51 years in the homebuilding industry from ditchdigger, to builder, to scientist, to engineer I have not seen such extremely disastrous times since 1931 and 1932.

Our massive housing characteristics data show that the NAHB members have made great strides since the oil embargo in improving the energy efficiency of homes we are building for the people of this Nation. Our Nation's big problem is that little building is taking place.

The homebuilding industry is, as I think you know, an industry of many small businessmen. In normal times, the typical volume is

perhaps 20 or 25 homes per builder. Many build fewer than 10 homes. No single corporation has more than 1 percent of the market and most of the time considerably less than that as is the case today. This enhances competition and enables the American consumer to have the best choice of housing in any country in the entire world. This disadvantage though is that these small businessmen cannot afford, because their customers cannot afford, a research program. The same is even more true of the solar industry, and it is also true of the subcontractors and the suppliers, architects, and engineers, and professionals who work in our industry. Very few builders have the inclination or the financial ability to undertake the risk of experimenting with unproven products, designs or technologies that may seem promising in small-scale laboratory studies or in theory but are unproven by research on actual homes.

No one that I know in the homebuilding industry believes that our country's energy problem is at an end simply because there is a temporary oil glut. As a matter of fact, builders and their customers know that we are facing a continuous relentless increase in the price of energy for heating and cooling. The reports that we have are that these will continue and in all likelihood be accelerated. The pressure is on our industry to try to build more energy efficient homes and we would like to do this. Customers would like to have them. But, there are many unanswered questions and subjects that still need research. There is still a substantial gap in the knowledge needed by the building industry to apply active and passive heating and cooling and conservation techniques.

Despite much of the fine work that has been done in the passive solar field, the building industry does not have the answers yet to the following fundamental questions: What is it? How do I install it? What will be its long-term performance? How much does it cost? What is the benefit to the buyer in terms of energy dollars saved versus additional cost? How does it produce a safe and more comfortable home? Is it marketable?

The DOE conservation and active and passive solar research programs have addressed a large number of important subjects mostly on a theoretical or laboratory scale basis, and that was a proper first step. But now is not the time to end these programs. However, it appears that for this present fiscal year the administration does not plan on continuing this approach and in fact is going to eliminate funding in these subjects for fiscal year 1983. This we believe is a mistake for several reasons which in the interest of saving time, I will not go into—it is in the written testimony. The bottom line of the result, however, is that additional research could save much more fossil fuel energy and lower the bills of people living in homes, apartments, and other kinds of housing.

I am not talking about vast sums of money compared to the technology programs DOE proposes to continue to fund in such fields as nuclear energy and advanced fossil fuel technology. In fact, even $40 to $50 million for the conservation and active and passive solar programs is quite small compared to the huge funds proposed for the other programs. By the way the NAHB is on record favoring a more balanced approach to funding energy research.

The present budget proposal for buildings research will have the effect of cutting off much needed high-risk research on full scale homes and of bringing to the useful stage much of the laboratory work that has been developed so far. It would also cut off the opportunity to target more research at end use applications. Public funds should result in research that can be applied by the people who pay for it and that, we think, is an important item.

While we have made some significant progress in passive solar research for space heating, the surface has barely been scratched in research for passive and hybrid cooling systems. As a matter of fact, there is a small amount of evidence that many of the elderly and thousands of other people living in trailers and mobile homes in Florida, the gulf coast area, Texas, Arizona, New Mexico, California, and in general the Sun Belt, might be able to substantially reduce their extraordinarily high cooling costs in these kinds of housing units with relatively simple passive solar techniques. But, this would require some full-scale research to measure performance and find out how much it costs and find out how to do it most efficiently. These are generally the people who can least afford wasted dollars.

Not all of the needed research is in the field of full-scale buildings performance. For example, there are some very important materials research needs which we see no manufacturer being willing to undertake because of what they believe would be a limited and perhaps chancy market if the tax subsidies for active solar and related programs are removed. We need fundamental polymer research, for example, to try to reduce the cost of materials for active solar systems; physical chemistry research to facilitate coolness storage that has the ability to absorb heat and alleviate the problems of most of the Nation's electric utility companies in their peaking problems in the summertime, which will surely result in a requirement to add new capacity unless we do something about it which in turn will be very high cost capacity.

Research on solar assisted chemical dehumidification, for example, is another subject. In climates like we have along the east coast and the gulf coast and with today's level of thermal protection in new homes and passive solar techniques, plus some natural ventilation, additional air motion, and, perhaps, solar-assisted chemical dehumidification, we might get much closer to a zero energy requirement homes.

The new research—continuing research—program ought to have several major thrusts, we think in cost effectiveness, in the measurement of actual performance of homes and buildings, improving the operating reliability and durability of some of the solar components and systems; in bringing the new technologies to a confidence level so that builders, engineers and architects will not have to experiment with the customer's money in adapting these techniques.

Finally, funding is badly needed to translate the results of such research into forms that can be used by the people that need to use it: builders, architects, engineers, contractors, manufacturers and others in the industry.

I believe that it is reasonable to expect that if the solar and conservation programs are extended another 2 or 3 years with some

redirection, we can expect half a million solar homes to be built 5 years from now, that is per year. I think if the cooling program is taken into account and extended, we might expect, in 7 or 8 years, as many as 1 million such homes to be built per year providing the industry is allowed to return to a normal level of production.

We regret very much th termination of the regional solar energy centers. In our view hey were doing an excellent job of translating research results f.om the laboratory and putting theory into practice. They were a great help to the building industry and to many of the people that are in that industry. Hopefully, the Congress will see its way clear to restoring their functions.

So, too, do we regret the decline of the building program in the Solar Energy Research Institute. This was a most useful program. It was very sensitive to the needs of the building industry and the problem of bringing effective utilization of solar energy to the people. We urge reinstatement of that program.

Mr. Chairman, I also want to address the idea of a building energy research program. We believe that such a program has much merit if it is structured properly, has the right goals and is designed to undertake projects that reflect the needs and energy problems of the building industry and the people it serves.

The program should be much more end-use application oriented and, also, it should reflect an understanding of the building industry. Obviously there would need to be some coordination if that program were in DOE with the Department of Housing and Urban Development and, perhaps, the family housing divisions of the military services, organizations of the energy sections of the National Bureau of Standards and others.

A building energy research program combining conservation, active and passive solar and the application aspects of photovoltaic, biomass and other renewable energy technology just makes fundamental good sense in a Nation that is hard-pressed to conserve energy now and for at least several generations in the future.

I have listed several—six, as a matter of fact—categories which that research could continue. We, too, will have a more specific statement on that later to be submitted to you.

Whether DOE continues as a Cabinet-level department or its functions are transferred to another agency, I believe a more comprehensive and balanced approach to building energy research is both essential and appropriate.

The issue of balance should also be applied to DOE's entire energy budget.

We applaud every effort of the Congress and the administration to review all Federal expenditures in the crucial battle against inflation and high interest rates. Every dollar DOE, and for that matter, all Federal agencies spend, should undergo the same review: Is it necessary? Is it a wise investment of funds that will produce results that can be used? Is there a proprietary interest such that the research could or should be funded by the private sector? And, perhaps, many others. We believe that the answer to

these questions, when applied to the type of research I have mentioned above, is affirmative.

Thank you for the opportunity to present our views, Mr. Chairman. I will be happy to try and answer any questions.

[The prepared statement of Mr. Johnson follows:]

Statement of the NATIONAL ASSOCIATION OF HOME BUILDERS before the

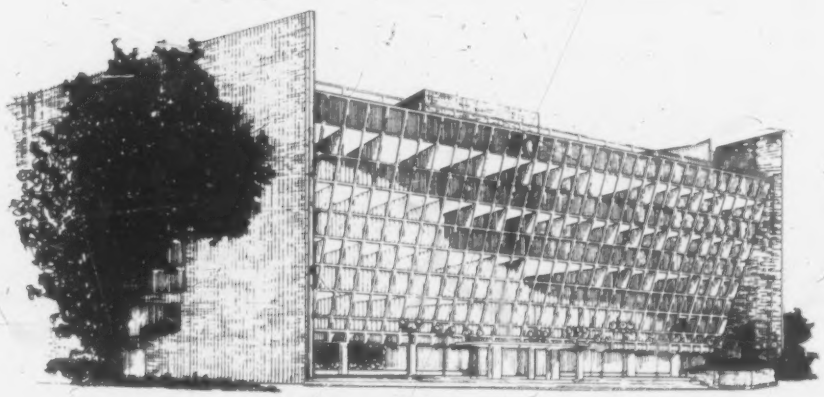
Committee: Subcommittee on Energy Development & Application of the Committee on Science & Technology

Subject: The Department of Energy's Conservation & Solar Programs

Witness: Ralph Johnson

Date: March 11, 1982

Place: Washington, D.C.



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STATEMENT OF

RALPH J. JOHNSON

before the

SUBCOMMITTEE ON

ENERGY DEVELOPMENT AND APPLICATIONS

of the

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

on

THE DEPARTMENT OF ENERGY'S CONSERVATION AND SOLAR PROGRAMS

March 11, 1982

Mr. Chairman and Members of the Subcommittee:

My name is Ralph Johnson, and I am president of the NAHB Research Foundation, Inc., a not-for-profit subsidiary of the National Association of Home Builders (NAHB). I am testifying today on behalf of the Research Foundation and the more than 116,000 members of NAHB who, in normal times, employ over three million workers. NAHB is the trade association of the nation's homebuilding industry. With me today is Joe McGuire, NAHB's Director of Regulatory Affairs.

The NAHB Research Foundation was formed for the purpose of performing research, development and studies that would lower the cost and improve the value of homes, apartments and light commercial buildings. We perform this work for industry and government as well as NAHB.

Mr. Chairman, thank you for the opportunity to appear before the Subcommittee today to present our views on DOE's conservation and solar programs for FY'83 aimed at the building sector.

I appear before you with more than 35 years of professional experience in housing and home building; as the recent author of the Builders Guide to Solar Energy; the developer of a number of energy conserving research homes, the first of which we built in 1956; as a person who attended his first solar energy meeting in 1955; the author of an Insulation Manual for conserving energy in homes and apartments in 1969; the co-author of the NAHB Thermal Performance Guidelines for Homes and Apartments developed in 1976; and as one who has been engaged in much research and development effort pertaining to practical energy conservation and the application of passive and active solar energy to homes and apartments.

I should also tell you that I have a bias. I believe, however, it is realistic and practical. For the more than 25 years that I have been involved in technical research and studies with NAHB and the Research Foundation, I have been concerned with energy conservation and the beneficial use of the sun's energy. The first research home that we designed and built in 1956 had a number of energy conserving and passive solar design features. For many years we have been in the forefront of activities aimed at reducing the cost, improving the value and comfort of homes, and reducing operating cost for energy on a practical basis.

Before I comment on the DOE proposals for FY '83, I would like to present some facts on the current state of the homebuilding industry. To put it bluntly, the home building industry has just finished its worst

year on record. On top of that, NAHB forecasts that housing starts for 1982 will be at the lowest levels since 1946. Many members of NAHB are experiencing severe financial difficulty or have gone out of business. In addition:

- o January was the sixth straight month in which the seasonally adjusted housing starts rate was below one million.
- o Building permits in January were 31 percent below the January 1981 level.
- o Total housing starts for 1981 (1.101 million) were down 16 percent from 1980 (1.31 million) - which in turn was 25 percent below 1979 (1.760 million) the 1979 figure was 14 percent below the 2.036 million starts achieved in 1978.
- o Unemployment in construction in February was 18.1 percent, more than twice as high as the overall unemployment rate.
- o In my 51 years in homebuilding, from ditch digger to builder to scientist and engineer, I have not seen such extremely disastrous and perilous times, except for 1931-32.

Our massive housing characteristics data show that NAHB members have made great strides, in the years since the oil embargo, in improving the energy efficiency of the homes they build today. Our nation's big problem is that little building is taking place. The many thousands of builders facing the stark reality of the bankruptcy courts have little time to search for ways to build more energy efficient homes. Rather, they and consumers are wondering if interest rates will ever make homes affordable again. This is not to say that energy conservation is not a priority, but rather too many builders are not building homes at all, let alone energy efficient homes.

Today's more energy conserving homes represent the first step in expanding the application of passive solar heating and cooling techniques. There are success stories from a few builders in various parts of the country who have been able to experiment with the latest in energy efficient active and passive solar home designs and products. Unfortunately, for the vast majority of home builders, this luxury does not exist. The home building industry is an industry of small businessmen. The typical NAHB member in good times only builds 20 to 25 homes per year. A number build fewer than 10 homes per year. The largest building firm has no more than 1% of the market. This enhances competition and provides the American home buyer with a much greater housing choice than in any other country in the world. The disadvantage is that these small businessmen cannot afford, because their customers cannot afford, research programs. The same is even more true of the solar industry.

The very nature of the home building business is one of high risk. But very few builders have the inclination or financial ability to undertake the risk of experimenting with unproven products, designs or technologies that may have seemed promising in small scale laboratory studies, but are unproven by research on actual homes. Those builders who do experiment do so with full knowledge of a financial commitment over a long period of time, for they know they cannot experiment with the customer's dollar in such a precious product as his home.

No one that I know in the home building industry believes that our country's energy problem is at an end simply because there is a temporary oil glut. Even with imported oil at its lowest level since 1976 our

country is critically dependent daily on huge quantities of imported oil, primarily from areas of the world where, at best, future supply must be classed as uncertain.

In truth, builders and their customers know that, while the price of oil may have been shaved somewhat in the international markets, there is a relentless and, in some cases, sharp series of increases in the cost of gas and electricity for heating and cooling homes, apartments and buildings. The reports are that these increases will continue and, for some fuels, will in all likelihood be accelerated.

The pressure is on the building industry to build more energy efficient homes. Builders want to do this, and their customers want those kinds of homes, apartments, mobile homes and light commercial industrial buildings. But there are many unanswered questions and subjects that still need research.

There is still a substantial gap in the knowledge needed by the building industry to apply active and passive heating and cooling and conservation techniques. I would like to try to make it very clear that there is indeed a significant gap between what we now know and what we need to know, particularly in the passive solar field, in order to apply it to homes and buildings without putting the research risk on the backs of already over burdened home buyers. Despite much of the fine work that has been done in the passive solar field, the building industry really does not have the answer yet to the following fundamental questions:

- o What is it?
- o How do I install it?
- o What will be its long-term performance?
- o How much does it cost?
- o What is the benefit to the buyer in terms of energy dollars saved?
- o Does it produce a safe and more comfortable home?
- o Is it marketable?

The DOE conservation and active and passive solar research programs have addressed a number of important subjects mostly on a theoretical or laboratory scale basis. And that was a proper first step. But now is not the time to end these programs. Up until the present fiscal year, these programs have been aimed in the right direction: trying to answer questions that the industry can not. However, it appears that for this present fiscal year the administration does not plan on continuing this approach and, in fact, is proposing to eliminate funding in these subjects for FY 83. This, we believe, is a mistake for several reasons. First, by terminating funding for these programs before their completion, valuable laboratory scale information that has been developed will not reach those in the building industry who can translate it into more energy efficient homes.

It is unfortunate that the passive and active solar programs apparently do not fit into the present DOE philosophy of funding only long-term, high risk research. It seems to me that many projects do indeed fit this category. The nation faces a high risk for at least several generations if the knowledge already obtained is not translated into information that the building industry can use through the continuation of these research

programs for the next three years or so.

Second, the value of continuing the passive and active research programs to completion far outweighs the cost of losing the valuable information that could become available to owners and occupants of homes, apartments and other buildings.

Third, there remain some very important research projects that can help answer the questions and solve the problems of many builders and future home occupants. I am not talking about vast sums of money compared to the technology programs DOE proposes to continue to fund in such fields as nuclear energy and advanced fossil fuel technology. In fact, even $40-50 million for the conservation and active and passive solar programs is almost microscopic compared to the huge funds proposed for the other programs. The NAHB is on record favoring a more balanced approach to funding energy research.

I would like to give you a few simple examples of subjects that still need research. The conservation program in DOE, as part of the Building Energy Performance Standards (BEPS) program, funded the development of a massive computer program called DOE 2.0A, and subsequent modifications, to predict energy use. In two very carefully monitored, occupied, side-by-side research homes - one a conventional comparison home and the other an advanced energy saving home using off the shelf products but not passive solar, the computer program predicted energy use for space heating 81 and 87 percent higher than actual use over a one year period. It predicted 31 and 32% less than actual energy use for space cooling. Incidently, in that research, conducted by the Research Foundation and

funded by HUD, we were able to show 70% reduction in energy for space heating, 49% reduction for water heating and 30% reduction for space cooling even though the homes essentially looked alike. We need a validated method that the typical building firm, HVAC contractor, engineer and architect can use to predict energy use. Only the government can afford the funding for such a program. And then it must be reduced to something that is feasible and practical for industry to use.

Just a few days ago a builder who has been building advanced energy conserving and passive solar homes and who is a very devoted and enthusiastic student of these subjects said that his customers are now experiencing a comfort problem. This has never been modeled in any of the computer programs nor uncovered in any of the laboratory box experiments that have been undertaken (nor would it be). In most of the populace sections of this country there are frequent winter periods of several days or more of cloudy skies with no or very little solar gain. The large thermal storage mass in passive solar homes cools down. The body radiates heat faster to these massive heat sinks and so the people feel uncomfortable unless they raise the thermostat, in some cases substantially. This increases energy use. The point is long-term, high-risk research is needed to measure and learn much more about the effect of theoretical and laboratory scale techniques when they are moved into the full scale home, apartment or building.

In another example, nearly identical side-by-side homes, one with 150 sq ft and the other with 255 sq ft of south-facing glazing, had almost identical energy consumption for space heating over a three month period this winter. These were unoccupied. So according to theory,

there should have been a substantial difference in their performance. It is obvious that there are some important things that we don't know yet.

The present budget proposal for buildings research will have the effect of cutting off much needed high risk research on full scale homes and of bringing to the useful stage much of the laboratory work that has been developed so far. It would also cut off the opportunity to target more research at end use applications. Publicly supported research, aside perhaps from some very fundamental work, should be aimed at being able to positively answer the question: if the research is successful can it be applied beneficially for public use? Much more research of this type needs to be undertaken in the buildings field.

The maximum benefit from buildings research can not be obtained by relying solely on bench or laboratory research and development. While there is need for more theoretical and laboratory research in some subjects, such as the physics of changing the heat transfer characteristics of glazings, there are certain key barriers to the more widespread use of solar energy in homes and apartments. Simply stated, careful, documented full scale field research on occupied homes and buildings in a number of locations is necessary to obtain sound answers to the questions I mentioned before. Thus, it is not enough to just perform the back-up long range technological research. It is essential to carry on the additional applied research that will provide the practical answers that are needed and to package and distribute those results in a form that can be used by the industry. These kinds of efforts are well beyond the

resources of even the largest building firms, and no manufacturer will support it because there is no proprietary interest.

It has been my observation that, for the most part, the passive and active solar programs for buildings have been effective. The objectives generally have been to develop the large leverage involved in moving the programs to the point where industry can indeed take over. As I see it, we are still two to three years away from that point for both passive and active (in some markets) and probably another two or three years farther away for cooling.

For example, while we have made some significant progress in passive solar research for space heating, the surface has barely been scratched in research for passive and hybrid cooling systems. In fact, the massive computer programs developed with DOE funding, such as DOE 2.0A, etc., and BLAST 3.0, predict only relatively minor annual energy savings for passive heating systems, in the southern half of the country where cooling energy is a critical issue for both consumers and utility companies. There is a smattering of evidence that hundreds of thousands of elderly and other people living in trailers and mobile homes in Florida, the Gulf Coast area, Texas, Arizona, New Mexico, California and in general the sunbelt, might be able to substantially reduce their extraordinarily high cooling costs with a relatively simple passive solar technique. But this would require some full scale research to measure performance, cost and determine how to do it most efficiently.

In short, much more research is needed in what might be called the science of thermal performance and heat transfer along with ground coupling in the various types of homes, apartments and light commercial/industrial buildings.

Not all of the needed research is in the field of full scale buildings performance. For example, there are some very important materials research needs which we see no manufacturer being willing to undertake because of what they believe would be a limited and perhaps chancy market if the tax subsidies for active solar and related programs are removed. We need fundamental polymer research, for example, to try to develop low cost glazings and collectors and to develop techniques to produce durable high reflectance mirror type substrates for all kinds of solar heating and lighting applications.

We are a long way from having the answers that industry can use in terms of the physical chemistry of various types of chemicals for the storage of heat and for the storage of the ability to absorb heat or as is sometimes referred to, "coolness storage." Almost all of the southern electric companies and many others, some even as far north as Boston, have critical summer peaking problems. Research is needed on passive and hybrid cooling and conservation to develop materials and systems that will assist the people and utility companies in the air conditioning areas of this country to alleviate the summer peaking problem and thus reduce the need for what is certain to be high cost new capacity.

Chemical research in the application of new types of heat pumps and chemically driven dehumidification systems are also important. In the engineering and architectural field, daylighting of buildings is just one example of needed additional research. Whether is is engineering or materials research is not consequential, but there are exciting and

potentially very beneficial opportunities in the field of switchable materials - i.e., coatings for changing the heat transmission properties of glazings and for the development of windows and movable "insulation" for glazing systems that perform far better than they do today.

It seems to me that continuing research in the solar and conservation field should have several major thrusts. First, research should be aimed at increasing the cost effectiveness of various kinds of techniques by reducing the initial cost and improving the performance. The second major thrust I have mentioned several times, and that is to perform research to find out how the combination of conservation and solar techniques really perform in actual homes and buildings, what do they cost and how is the best way to do it. A third major area for research relates to improving the operating reliability and durability of various solar components and systems. Fourth, federal research support to bring the new technologies to the point where industry can use them with confidence seems to be an essential part of bringing this nation to the point where we can be much more energy independent and obtain a much larger proportion of our energy from the sun. Finally, funding is desperately needed to translate the results of this research into forms that can be put to use by builders, engineers, architects, contractors, manufacturers and others in the industry.

I believe there is a tremendous potential for energy saving using passive solar technologies for residential and light commercial buildings. With the continuing increase in the levels of thermal protection that

the industry is now building into new homes, coupled with active or passive water heating and passive heating, the typical home today might be moved very close to having minimal energy requirements for heating. I believe it is reasonable to expect that as many as one-half million new passive solar heated homes a year would be built five years from now if the passive solar program is supported at a level that will enable it to continue the momentum that has been developed. That means less dependence on foreign oil, a lower balance of payments deficit, more jobs and more families with lower utility bills.

Research is just getting underway on passive and hybrid solar cooling. This makes good sense because as the need for cooling is increased, the availability of the sun's energy is increased. This is just the reverse of the situation for solar heating where as the need increases the available solar energy decreases. Also, active solar cooling systems help make active solar space heating more economically feasible. With appropriate support for cooling, both passive and active, as well as passive solar and conservation, I believe it is reasonable to expect one-million homes a year to be built using those technologies seven or eight years from now - assuming of course, the industry is allowed to return to a normal production level.

But these levels of utilization of solar in buildings will surely not be achieved in anything like that kind of time span without continuing federal support at a significant level.

Research on needed passive solar products, including cost sharing incentives for product development to manufacturers is another very important, but modest, passive solar program. There are very few passive solar products that will pass the acid test of the real estate appraiser and lender to get credit for full value. Actually there are a number of needed passive products that don't even exist as I previously mentioned. Some of the basic technologies

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are known, but without some incentive and without an obvious growing passive solar market, manufacturers are not going to spend large sums of money on product development for a questionable market. Without the products, the homes cannot be built.

Research on existing homes and buildings is extremely important. We need to find out much more than we now know about the effect of combinations of various energy conserving techniques on homes and buildings and how to cost effectively add passive and active solar systems. As research subjects these have hardly been touched. Excluding manufacturing facilities and massive buildings, the largest opportunities to save energy are in existing light commercial industrial buildings, existing housing including trailers and mobile homes, new light commercial industrial buildings and new homes and apartments, probably in that order. There are many high risk research possibilities for applying innovative combinations of techniques to existing homes and buildings to take advantage of solar energy and conserve fossil fuels. This work has barely begun by DOE, yet no one in the home building or manufacturing industries has sufficient proprietary interest to fund such research. A manufacturer is hardly likely to fund research to find out whether his product or another entirely different product is more effective. If he does, only the beneficial results will be published.

We regret very much the termination of the Regional Solar Energy Centers. In our view they were doing an excellent job of translating research results from the lab and theory into practice. They were a great help to the building industry. Hopefully, the Congress will see its way clear to restoring their functions. So too, do we regret the decline of the building program in the Solar Energy Research Institute. That was a most useful program. It was very sensitive to the needs of the building industry and the problem of bringing effective utilization of solar energy to the people. We urge the reinstatement of that program.

Building Energy Research Program

Mr. Chairman, I also want to address the idea of a Building Energy Research Program. We believe such a program has much merit if it is structured properly, has the right goals and is designed to undertake projects that reflect the needs and energy problems of the building industry and the people it serves. The program should be much more end use application oriented, should be screened at the concept stage and while ongoing to obtain industry guidance and assistance. Also, it should reflect an understanding of the building industry.

Further, it seems appropriate that it should be undertaken not only in close cooperation with industry, but in consultation and coordination with the Department of Housing and Urban Development, the family housing divisions of the military services, the energy sections of the National Bureau of Standards of the Department of Commerce; and on some subjects, such as indoor air quality, with EPA and the many federal agencies concerned with health sciences, and perhaps other federal agencies.

There is little question that in the past DOE's buildings program has fallen short in an attempt to influence the way homes and buildings are constructed. Too often in the past the solution to a problem was viewed as the development of an onerous mandatory regulation. In this regard I am reminded of the method the District of Columbia and surrounding counties use to solve the snow traffic problem. They pass laws imposing a $500 fine if you get stuck.

DOE's Building Energy Performance Standards are a prime example of this approach and a lack of understanding of the building industry and its many constituents including state and local building regulatory

officials who were supposed to enforce the program. Giant computer models developed in the national laboratories, using best guess algorithms, have little chance of arriving at answers that are economically sound and that can be understood and enforced by the thousands of the nation's building officials, let alone be understood by the industry and home buyers who would be forced to foot the bill. The added costs and delays that would have been required to comply with such regulations would have far outweighed the potential energy savings.

A building energy research program combining conservation, active and passive solar and the application aspects of photovoltaic, biomass and other renewable energy technologies, just makes fundamental good sense in a nation that is hard pressed to conserve energy now and for at least several generations in the future.

While there are a number of ways to categorize the kinds of research activities that make sense for federal support, programs in the following general areas are needed:

1. Fundamental Research.

   For example, research on indoor air quality issues to determine whether they are problems, if so, under what conditions, and how to eliminate or alleviate them. Research on phase change low mass thermal storage components, research on dehumidification, glazing systems, daylighting and many others.

2. Performance of Occupied Buildings.

   I have already mentioned this subject but it includes actual measurements, interpretation and evaluation of the performance of combinations of homes and buildings, their cost, their

effectiveness and their influence on safety, health and comfort; research on the measurement, cost and performance of a number of retrofit technologies, and others.

3. Prototype Development and Applications Engineering Performance Measurements.

For example, research on development of lower cost integrated modular and backup heating systems; development of low cost energy saving construction processes and modular elements; and development of new components for thermal storage.

4. Cost and Performance Data Collection and Analysis.

For example, collect and analyze cost and performance data on innovative technologies in a variety of climatic regions for both new and existing residential and commercial applications.

5. Development of Design and Analytical Methodologies.

For example, develop programs to accurately predict the energy use of residential and commercial buildings and the effect of modifications to their design; and development of much needed design tools.

6. Technology Transfer and Dissemination.

Without this activity, the benefit of the research dollars will not be realized. The information must be targeted for the specific audience: builder, consumer, building official, utility, engineer, architect, contractor, mortgage lender, appraiser, and others.

Whether DOE continues as a cabinet level department or its functions are transferred to another agency, I believe a more comprehensive and

balanced approach to building energy research is both essential and appropriate.

The issue of balance should also be applied to DOE's entire energy budget. Certain technologies such as nuclear and fossil energy research continue to receive substantial amounts of federal assistance, while the minimal amount of dollars earmarked for less exotic energy priorities such as passive solar, are terminated. This doesn't seem to be a well balanced national energy policy and we urge this committee to scrutinize very closely the budget request.

We applaud every effort of the Congress and the Administration to review all federal expenditures in the crucial battle against inflation and high interest rates. Every dollar DOE, and for that matter, all federal agencies spend should undergo the same review: Is it necessary? Is it a wise investment of funds that will produce results that can be used? Is there a proprietary interest such that the research could or should be funded by the private sector? We firmly believe that the answer to these questions, when applied to the type of research I have mentioned above, is affirmative.

I hope my remarks have shown that there is a real need for continuing a proper federal role in buildings energy research including active and passive solar and conservation and that this will be in the best interest of the nation.

I thank you for this opportunity to present our views and would be happy to answer any questions.

Mr. FUQUA. Thank you very much, Mr. Johnson. I appreciate your statement. It seems as though three of you have said that you think we need to further the programs in the solar and conservation, particularly the buildings and passive programs. Mr. Ames has taken a different position.

Mr. Ames, first of all, I want to congratulate you on your statement and I know you are sincere when you say that. I want to congratulate you also on being an innovative builder and seeing the future in moving in that direction. I notice that you mention in your statement that you attended three different conferences, the Iowa Solar Operational Results Conference sponsored by the Iowa State Solar Office and the Iowa Energy Council and the Community Action Research Group. Do you know who funded those?

Mr. AMES. Yes, I do. It was under a Department of Energy grant. I might also mention at this time that the last few solar seminars that I have worked with the Iowa Energy Policy Council on, have had very poor attendance. People are just solared out. They have got the information they want and they actually want to see somebody doing something with it now rather than learning about it because they have already learned about it.

Mr. FUQUA. I could not agree with you more. I think that people do want to get moving.

I remember back in the 1800's in the U.S. Senate one distinguished Senator proposed that we abolish the Patent Office because everything had been invented that could be invented. Also, a great statesman who has gone down in history as a man of foresight, Daniel Webster, said he was not going to spend any of the taxpayers money in the State of Massachusetts to extend the railroad to the West, It was just a vast wasteland out there and there was no need to do that. I am glad that he did not prevail at that time because I think the West has contributed a great deal to this country and to its development.

I would like some time, if you could, for you to go to some of the national labs where they are doing very important work in nuclear fission and fusion and some other things. You said that we should abolish the Department of Energy. The President has only proposed transferring it, not abolishing it, because he feels that those programs—I assume he feels that they are important. Some of the very fine basic work that goes on in Mr. Dunn's district at Michigan State University. At Iowa State, I know particularly of the very fine agricultural school that they have there. They do an outstanding job in agricultural research and it has helped our farmers for many years. That is true in a lot of States, particularly at the land grant college universities—where they have been very helpful.

Getting back to the subject of the hearing, there is a feeling that in photovoltaics and some other solar energy systems some that we have found all that we need to know about them. Do you agree?

Mr. AMES. I think it should be turned over to the private marketplace to let them develop it. I did my own developing of my passive designs. I could have applied for a grant from the Government to help do research on this but I chose not to. I had the attitude that if a project could not be developed by a private individual and marketed and ultimately sold that it should not be marketed in the first place.

Mr. FUQUA. Mr. Bullock, would the AIA be able to improve its energy education programs without the DOE research or funding?

Mr. BULLOCK. I do not think we could go much further than we are right now, Mr. Chairman, without further in-depth research. What we are teaching our members now in our three-level seminars is just about at the state of the art right now. We know that there is an awful lot out there, especially in the area of modeling where you need to address all three or four factors that affect the building energy performance .

Mr. FUQUA. Mr. Johnson mentioned the scale of funding and the need for testing.

Mr. BULLOCK. The scale, the testing, the orientation, the tradeoffs, the tremendous difference in climatic conditions we have from Miami to Iowa.

Mr. FUQUA. I was going to point out when you started talking about passive heating that that is fine in some of the colder areas but it sure does not help us in the summertime down in Florida.

Mr. BULLOCK. We would really like to solve our humidity problem.

Mr. FUQUA. We have been spending some money on development of improved and more efficient heat pumps——

Mr. BULLOCK. Yes, we have. Compressed air to air in the water solar system.

Mr. FUQUA. As a matter of fact now, I think we have an energy efficiency ratio of about 5 to 1 and with the new generation that has been developed and funded by DOE, it is around the 13-to-1 figure. I have talked with companies like Carrier and some others that have said that had it not been for that type of basic research they would never have been able to move. They have taken the research and applied it to their commercial commodity.

Mr. BULLOCK. We are totally in concurrence with that philosophy.

Mr. FUQUA. Ms. Bleviss, you raised a concern about whether or not the marketplace would pick up the conservation technologies. I think you said that you did not think that the marketplace would pick them up. Should we continue to fund programs and research them to death without getting them into commercial markets? How do we address that question?

Ms. BLEVISS. I think one of the reasons, in fact, why we are working with the homebuilders and AIA right now is because we recognize that one of the failings of the existing research program is that it has not done a very good job of trying to work with end users very well. It has made some progress and there have been successes but not enough. We clearly agree that there is a problem there but you need the research before you can take it into the commercial end.

Mr. FUQUA. That is one of the concerns that we have. How do you get your research results into the commercial sector for it to be used.

I want to commend you for trying to coordinate and work with the architects and homebuilders in trying to find out what the market needs. I think that is very important. We do not need a lot of research that does not have commercial application.

Mr. Ames you have a friend here and a fellow homebuilder, Mr. Dunn. I am going to yield now to Mr. Dunn for some questions.

Mr. DUNN. I thank you, Mr. Chairman.

This is the first time in 1½ years that I have felt like asking one of the witnesses if he would like to have a beer after the hearing.

I think the problem we face in the committee is that all four of you, even though you are saying divergent things, you are all correct. I think Mr. Ames has correctly delineated the frustration that my fellow members of the homebuilding industry feel about Government involvement and the frustration in terms of interest rates and lack of program dissemination and the frustration in terms of the lack of progress.

Even in Ms. Bleviss' testimony, she highlighted some of the things that DOE has done, including the water heat pump, an idea that has been around for 25 years.

You talked about the progress in urban waste programs, There are many urban waste projects already operating without Federal Government support. You talked about the BEPS and building energy performance standards, the appliance standards. That is a problem that Mr. Ames has with the Federal Government and DOE—14 million dollars' worth of basic research in the first few years on the appliance standards and the energy standards—probably a good use of Federal money.

Last year, DOE testified before this committee that they wanted $4 million just to write the standards—$4 million of our taxpayer's limited money—that is the frustration that he is talking about. That is what is wrong with the Department of Energy.

You talked about domestic oil reserves: You say they are going down. Discoveries in the United States, Canada, and elsewhere prove just the opposite. The world now has more energy in oil reserves than it has ever had in any point in its history; true, mainly the incentives of the private enterprise. So, while I think there is a place for all four testimonies, I suspect in the end that Mr. Ames is the more accurate. The architects say there is nothing left they can do to save energy. I already spent 2 days up in Canada in a 20-story building that not only does not use energy but is a net producer of energy. It is the biggest high-rise building in downtown Quebec and it not only supplies all of its own energy needs, but also contributes to a seven-story building next door as well—no Government funds were used. Some person, like Mr. Ames, is sitting down in his dark room and coming up with the idea. I suspect very strongly, and in particular, when you closely look at the history of DOE, that Mr. Ames is more correct than wrong and I thank you for your testimony.

Mr. FUQUA. I want to thank all of you for being here this morning. Are you a member of Mr. Johnson's association—homebuilders?

Mr. AMES. Yes, I am.

Mr. FUQUA. OK. I want to thank all of you for being here today. We appreciate your testimony and your taking time to be here.

Thank you all very much for coming.

The subcommittee stands in recess until Tuesday, March 16, at 9:30 a.m. in this room to receive testimony on the DOE conservation renewable energy programs from public witnesses.

[Whereupon the committee recessed, at 4:20 p.m., to reconvene on Tuesday, March 16, at 9:30 a.m.]

1983 DEPARTMENT OF ENERGY AUTHORIZATION

TUESDAY, MARCH 16, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to recess, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, Volkmer, Fish, Skeen, Sensenbrenner, Gregg, McGrath, Lowery, and Schneider.

Staff present: Martha Krebs, staff director; Eugene Frankel, science consultant; and Daniel M. Steinway, associate minority counsel.

Mr. FUQUA. The subcommittee will be in order.

Today we have outside witnesses on the Department of Energy's solar energy research development and demonstration programs.

Over the past 8 years, Congress has stated explicitly and repeatedly its view of the proper Federal role in renewable energy R.D. & D. The Solar Energy Research Development and Demonstration Act of 1974 instructed the administration to, "Initiate a research and development program for the purpose of resolving major technical problems inhibiting commercial utilization of solar energy in the United States." It also authorized, "A program to design and construct facilities of sufficient size to demonstrate the technical and economic feasibility of solar energy." The Geothermal Energy Research, Development and Demonstration Act of 1974 used similar language in authorizing an R.D. & D. program for that technology.

The Department of Energy Authorization Act of 1977 gave as a purpose of the agency: "To place major emphasis on the development and commercial use of solar, geothermal, recycling, and other technologies utilizing renewable energy resources."

In the Solar Photovoltaics R.D. & D. Act, the Wind Energy Systems Act of 1980, the Ocean Thermal Energy Conservation R. & D. Act of 1980—in all of this legislation, the message from Congress has been consistent and clear: we want a strong Federal leadership role extending through the demonstration and applications phase for renewable technologies. DOE's current position on solar energy seems to question this. In the fiscal year 1983 budget books they say, "By relying on the marketplace and private industry, it is no longer necessary for the Federal Government to support the devel-

opment, demonstration, or commercialization of solar energy, including research and development undertaken for the purpose of accelerating the introduction of new solar technologies."

This new policy raises a host of questions which we hope to better understand through these hearings. For example, have the major technical programs inhibiting commercial use of solar energy cited in 1974 been resolved? Is no more work required in this area? Has the technical and economic feasibility of solar energy been demonstrated to the satisfaction of the final users? Are the proposed budgets for photovoltaics, wind, and OTEC in any way consistent with the goals of the R.D. & D. acts or the activities mandated by those laws? Is the economic and energy picture so changed that the activities mandated by the solar legislation of the 1970's are no longer required?

We hope that our witnesses today will help give us some perspective on those very important questions.

In our first panel on solar thermal and photovoltaics we have Mr. Byron Washom, president of Advanco Corp.; Mr. Harold E. Seielstad, senior engineer, energy research department for Pacific Gas and Electric Co.; and Dr. Elliot Berman, senior scientist, ARCO Solar, Inc.

We will start off with Mr. Washom.

STATEMENT OF BYRON WASHOM, PRESIDENT, ADVANCO CORP.

Mr. WASHOM. Chairman Fuqua and members of the Energy Development and Applications Subcommittee, the Solar Thermal Division of the Solar Energy Industry Association appreciates this opportunity to review our technological achievements of this past year and to discuss the administration's proposed fiscal year 1983 budget for solar thermal.

The committee last year on this occasion responded favorably to the breadth and depth of my prepared testimony and the opportunity to engage in a lengthy question-and-answer dialog. Mr. Chairman, I am not one to tamper with success, so with your permission, I would request that the 39-page prepared testimony be entered into the record as submitted, to limit my oral presentation to 15 minutes and to reserve as much time as possible for questions and answers with the committee members.

Mr. FUQUA. We will certainly make that part of the record. If you can reduce that to about 5 or 7 minutes, we would be even more appreciative.

Mr. WASHOM. All right. Fine.

Mr. FUQUA. We do have another panel after this one.

Mr. WASHOM. Yes, sir.

Mr. FUQUA. I do not wish to impede your discussion in any way, but we may have some questions which may answer some of our concerns, too.

Mr. WASHOM. Fine, sir.

The support that this committee has provided the solar thermal program—if viewed as an investment—has yielded significant technological dividends that now indicate the true potential of solar thermal energy in supplying energy to this Nation, as well as a new source of employment

Equally rewarding is an emerging recognition of this potential, most notable of which is the Electrical Power Research Institute in their journal dated December 1981, which gave an excellent account of solar thermal terminology. This appears in my prepared testimony as appendix C.

Annually this committee, and industry, has taken the opportunity to note the speed and success by which we are proceeding through this technology pipeline.

This report today will answer your questions, sir, to provide the basis and justification for this committee to support a specific budget and schedule within certain solar thermal technologies. Industry seeks to have Congress act not as a technical referee but rather as a technical advocate for only those technologies that are now proving their viability.

Solar thermal technologies, as you know, concentrate solar energy in order to gain higher temperatures and efficiencies than found in those nonconcentrating technologies. This ability to concentrate solar energy makes the technology promising in terms of total national energy supply and economic competitiveness.

George, could we have the first map please?

[Vu-Graph shown.]

Mr. WASHOM. The accompanying map shows the regions of the greatest direct insulation for solar energy in the United States.

I am quick to note that although we have primarily a south and southwest base of an energy resource, the next Vu-Graph shows the distribution of the manufacturing for solar thermal equipment which is very nationwide.

[Vu-Graph shown.]

Mr. WASHOM. The Solar Thermal Energy Association is primarily involved in three solar thermal technologies: central receivers, parabolic dishes, and parabolic troughs.

The members of the Solar Thermal Energy Association with the Department of Energy have made important progress toward advancing these technologies. We have completed, or we are close to completing, an impressive group of systems level demonstrations as well as subsystem engineering experiments which I would like to highlight.

[Vu-Graph shown.]

Mr. WASHOM. The first is the Barstow facility, the 10-megawatt, Solar I project in Barstow, Calif., which has completed construction and is beginning the initial checkout. Turbine roll is expected for April of this year.

Solar I is a significant application in that for the first time we will have the opportunity to determine the performance, cost, and reliability of central receiver systems.

[Vu-Graph shown.]

Mr. WASHOM. This Vu-Graph depicts the situation when we are actually on sun. The receiver receiving the full thermal flux of the field is at the top.

[Vu-Graph shown.]

Mr. WASHOM. Our next Vu-Graph shows the 2.5-megawatt sodium receiver provided by the Energy Systems Group of Rockwell International at their own expense which is currently being

tested at the Central Receiver Test Facility at Albuquerque, N. Mex.

[Vu-Graph shown.]

Mr. WASHOM. The next Vu-Graph shows our Shenandoah project which provides not only electricity but also heating and cooling as a cogeneration project for a textile plant in Shenandoah, Ga.

[Vu-Graph shown.]

Mr. WASHOM. The next project is in the parabolic dish field. The Department of Energy has been coordinating the development of Rankine, Stirling, and Brayton engine cycles in this area. The view we see here in the foreground is taken in November 1981 which was the first on-sun test to produce electricity from a Stirling engine with a hybrid receiver. Further testing in February 1982 with the Stirling engine in a solar-only receiver mode produced a world-record performance of 22 kilowatts electric output with a sunlight-to-electrical-energy conversion in excess of 27 percent.

February also marked, in the foreground here, the first testing of the organic Rankine engine on the parabolic dish which produced 17 kilowatts electric and an energy conversion efficiency of 21 percent.

[Vu-Graph shown.]

Mr. WASHOM. The next Vu-Graph shows a recent parabolic trough system at the Haverhill, Ohio, United States Steel chemical plant. Here in the parab lic trough field I should stop and pause for a moment to note that we have the greatest amount of expertise and experience with parabolic troughs.

In successive projects with DOE and industry, our parabolic trough systems have demonstrated increasingly higher efficiencies, higher reliabilities, and lower costs.

The modular industrial solar retrofit program [MISR] represents the final step of Government support for parabolic troughs. Under MISR, five manufacturers are developing troughs which incorporate the latest advances in trough technology which are massproducible, and which can be provided in modular units. MISR will validate the modular system design concept and provide an orderly and satisfactory conclusion to federally sponsored, line-focus development. MISR testing is scheduled for the spring of this year.

[Vu-Graph shown.]

Mr. WASHOM. The next VuGraph shows an international project that the American industry and DOE are participating in at the International Energy Agency in Almeria, Spain where in the background you see a 500-kilowatt solar thermal generating plant from central receiver and then two 250-kilowatt parabolic trough projects.

Those systems on the left are from an American designer, Acurex. The ones on the right are from a German manufacturer, MAN.

Thank you, George.

There remains to be a much larger investment in research and capital equipment in order to reach commercialization, Mr. Fuqua. If an equitably structured partnership between private industry and the Government can be established to deal with the technical and economic risks, then I am confident that this investment will be made. The system test and evaluation for each of the solar ther-

mal technologies will represent that period of highest level of interaction between Government and industry. OMB recognized the value of this period in their solar thermal budget submittal by stating:

> Proof of performance is needed to assure user acceptance of this renewable energy source. Operations, reliability, economic, and environmental effects must be determined at the system level to provide a data base for decisionmaking by potential users in the utility industrial sectors.

Unfortunately, OMB's understanding of commercialization issues was not accompanied by any proposed funds except for the operation of Barstow in fiscal year 1983.

Industry is advocating in its fiscal year 1983 budget proposal that cost-sharing cooperative agreements or other appropriate devices be implemented for the remaining technical development program and system test and evaluation.

The scarce Federal dollars in this budgetary year can be leveraged, and mortgage-free programs can be created through cooperative agreements. Long-term R. & D. will continue to be performed as presently structured at our national laboratories, research institutes, universities, and private industry. However, this high-risk, high-payoff type research should never constitute more than 30 percent of the total solar thermal budget.

There is a sense of nervousness in making this proposition to the Government in the fact that two other critical links to our commercialization future are presently under seige. The first and most critical is that of the proposed repeal by the Treasury Department of the business energy tax credits of 15 percent. The Treasury's proposal ignored the resolution rider in the Energy and Water Development Appropriations Act for 1982 that the President did sign. Sixty-two Members of the U.S. Senate, 26[illegible] Members of the House, and 16 members of this subcommittee—or 70 percent—coauthored that resolution.

I want to parenthetically state that the Treasury's proposed repeal of the energy tax credit, if implemented, would eliminate all chances of energy contribution from solar thermal in this century. An articulate presentation of the facts and the arguments on this issue was prepared by STEA on this matter and it appears in appendix B of my testimony.

The second critical issue perplexing the industry is the court of appeals decision vacating two sections of the public utility Regulatory Policy Act. In my opinion, a legislative fix is now in order even though the Federal Energy Regulatory Commission has elected to proceed with a judicial appeal.

The offical STEA budget for fiscal year 1983 appears in appendix A in the prepared testimony. Time does not permit an item-by-item detail of that budget, but let me speak to the aggregate level.

The proposed Solar Thermal Energy Association budget for fiscal year 1983 is $59.5 million compared to the administration's request of $18 million. How reasonable is this request in light of the other budgetary process that we currently find ourselves in?

The proposed budget represents a near parity with the fiscal year 1982 level of $52.9 million, and it is still a full 43 percent below the fiscal year 1981 level of $138.2 million.

Industry was extremely encouraged when the Senate Energy and Natural Resources Committee, a week ago last, voted 16 to 3 to favorably report a proposal that would recommend an aggregate fiscal year 1983 DOE appropriation at the same level as fiscal year 1982.

As this proposal was translated to the Budget Committee, Senator Domenici indicated that the recommended level of the proposal was a sound fiscal recommendation. Other organizations that represent renewable energy on the Hill are in the process of preparing a coalition budget. I am fully confident that the level of $59.5 million for solar thermal will be contained within that coalition budget.

Mr. Chairman, today I have shown this committee the proof-positive technical dividends of the Federal investment in solar thermal technology. It indicates that the Government/industry partnership is producing new industries with a future capability of competing on an economically viable basis.

As our envelope of risks reduce, the Federal budgetary support will be commensurately reduced, and we have demonstrated this to be true in the parabolic trough industry.

Industry is increasing its private investment in these solar thermal technologies by advocating cost-sharing cooperative agreements, contingency liability agreements, and other similar instruments in order to leverage the scarce Federal resources that are available in fiscal year 1983 and in the out-years. We believe that such efforts should represent a standard by which all projects and all technologies are judged.

The level of partnership requested of the Federal Government is $59.5 million or $41.5 million above the administration's request. This difference is equal to a mere 8 hours of foreign oil imports, but it equates to whether or not there will exist a solar thermal industry to supply renewable energy and, of course, of new employment.

The American public continues to support the ethic of renewable energy technologies as a part of the energy supply mix. Let us continue this Government/industry partnership to make renewable energy sources the possibility that we can now all envision by the hardware that I have shown to you today.

We appreciate this opportunity to offer our position. We pledge our support to you in the implementation of this proposed budget, and I would welcome any questions you may have.

Thank you.

[The prepared statement of Mr. Washom follows:]

STATEMENT OF BYRON J. WASHOM, VICI CHAIRMAN, SOLAR THERMAL DIVISION, SOLAR ENERGY INDUSTRIES ASSOCIATION

ABSTRACT

After just a few years the government's investment in solar thermal technology is beginning to yield dividends. Within the central receiver, parabolic dish and parabolic trough programs, operable systems now exist. Largely as a result of government efforts, a solar thermal industry is beginning to develop in this country. Despite these advances, the federal government still has a major role to play in the development of the technology. Industry is prepared to make the most of federal funds through cost-shared agreements and other arrangements but, industry is currently incapable of assuming the total risk associated with bringing solar thermal systems into the marketplace.

We are at a crucial juncture in the development of solar thermal technology. Recent policy changes have left the future of the entire solar industry clouded with uncertainty. As presented, the Administration's solar thermal budget request is inadequate to meet the current development needs of the technology. When combined with the other threats that face the solar thermal industry, the proposed budget may be fatal. In order for solar thermal systems to realize their potential and become a viable part of our energy supply mix, the technology needs a higher level of support than the Administration proposes.

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INTRODUCTION

Mr. Chairman, members of the Committee, this is the third consecutive year that I have the honor of addressing you as a representative of the Solar Thermal Energy Association (STEA), a division of the Solar Energy Industries Association. In the two years since I first testified before you, many solar thermal technologies have moved from the drawing board into actual field tests. While important, these advances have not been dramatic enough to justify a FY 1983 budget that is tantamount to a phase-out of the program.

The solar thermal industry is currently working together with other renewable technologies. We are all advocating similar legislative, tax and budget approaches to solar energy. I hope that the members of this Committee in making budgetary decisions feel that they can act as an advocates for renewable energy technologies and not as a referees between the various alternatives.

The developing solar thermal industry in this country seeks to operate according to tried and true business principles. An essential part of business is the taking of risks; something that the solar thermal industry is prepared to do. Industry, however, is only capable of assuming risks of a manageable scale.

Solar thermal plants are large complex systems. Because no single industry is capable of manufacturing an entire system, there are inherent limitations on the degree to which manufacturers can eliminate risks from the technology. The major uncertainties that remain are on a system level and include issues of reliability, efficiency, and operation and maintenance cost. These system-wide risks can only be reduced with the assistance of government through system level tests and evaluation. I will explain this relationship between government and industry in greater detail but first let me review the Solar Thermal Program's most recent successes.

THE SOLAR THERMAL TECHNOLOGIES

Solar thermal technologies track the sun and concentrate solar energy in order to gain higher temperatures and efficiencies than those found in non-concentrating technologies. This ability to concentrate solar energy makes the technology promising in terms of total national energy supply and economic competitiveness. The output from these technologies can occur either in the form of electricity, industrial process heat, mechanical energy, cogeneration or fuels and chemicals. The accompanying maps show the regions of greatest solar insolation in the United States and illustrate that solar thermal manufacturing occurs nationwide.

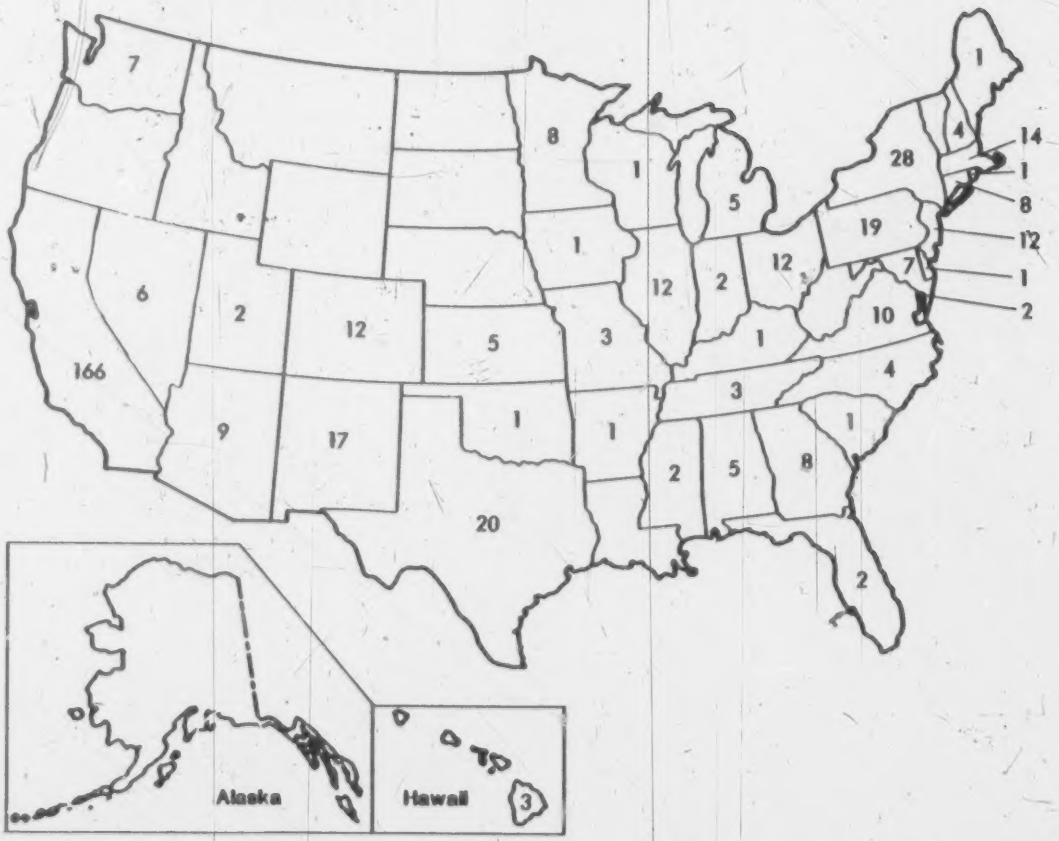
Solar Thermal Energy Association members are involved in three solar thermal technologies: central receivers, parabolic dishes, and parabolic troughs. Each technology has its own particular design advantages and range of applications and all are capable of supplying clean cost-competitive energy by the end of this decade. Working with the Department of Energy, STEA members have made important progress towards advancing these technologies. We have completed, or are close to completing, an impressive group of systems level projects and supporting subsystem experiments which I would like to highlight for you.

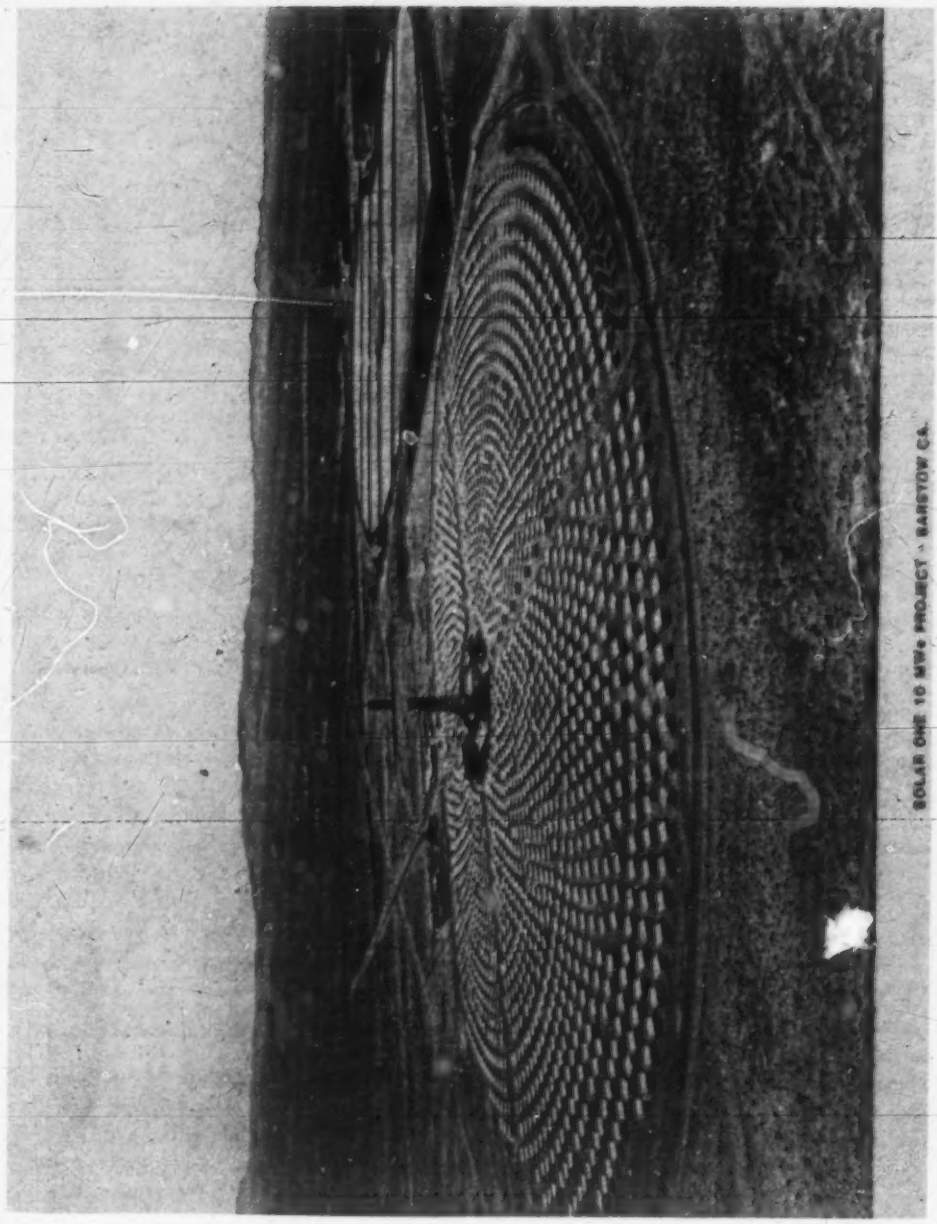
Solar I - Barstow

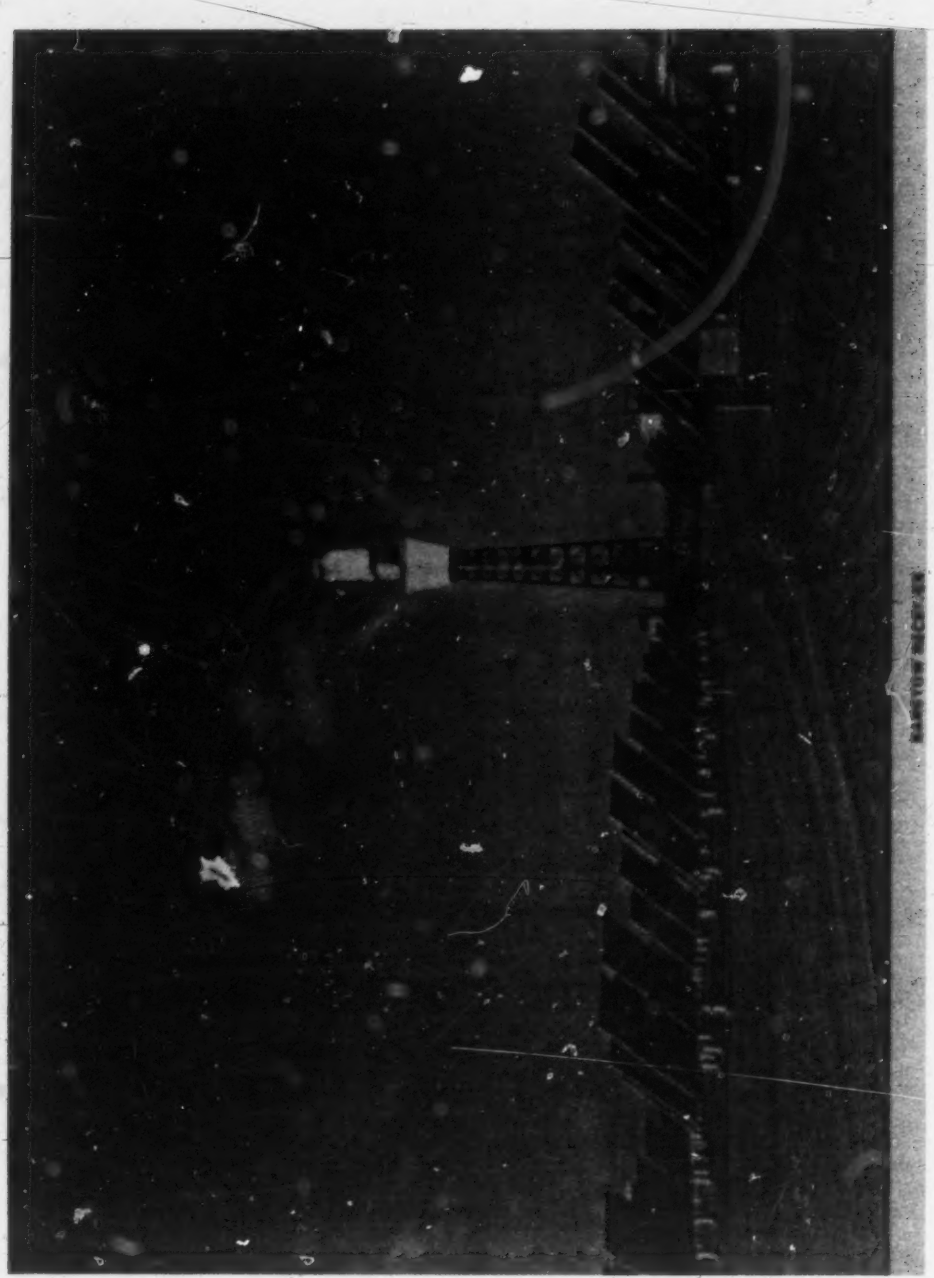
The construction is completed and initial check-out is underway on the 10 MWe Solar I pilot project. This pilot plant is the largest completed central receiver system in the world and illustrates the leadership of the United States' government and American manufacturers in central receiver technology. The completion of Solar I is significant since this milestone is essential in providing data on the performance, costs, and reliability of central receiver systems. Turbine roll is scheduled for the spring of 1982. This project

U.S. Direct Normal Solar Radiation
(Daily Mean, kJ/m²)
Over 26,000
22,000 - 26,000
18,000 - 22,000
14,000 - 18,000
10,000 - 14,000
Under 10,000
SERI

SOLAR THERMAL INDUSTRIAL SUPPLIERS PARTICIPATING IN DOE PROGRAMS (NUMBER PER STATE)




SOLAR ONE 10 MW₀ PROJECT - BARSTOW CA.



illustrates the federal role in assembling industry teams for subsystem design, fabrication and test.

Solar I is also significant as a model of cooperation between government and a public utility. The project is a cost-shared cooperative effort involving the United States Department of Energy, the Southern California Edison Company, the Los Angeles Department of Water and Power, and the State of California.

Sodium Receiver Test

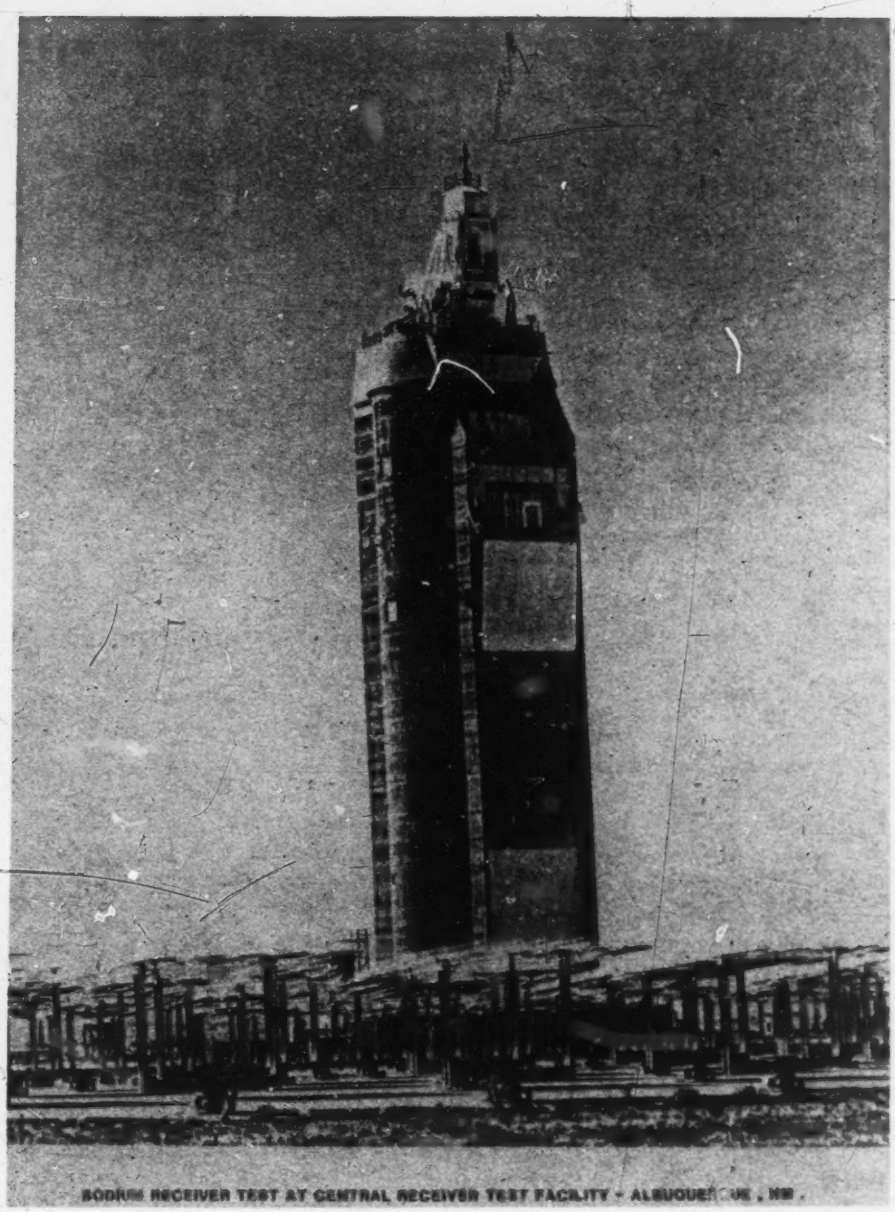
A 2.5 MWt sodium receiver, provided by the Energy Systems Group of Rockwell International at their own expense, is currently being tested at the Central Receiver Test Facility in Albuquerque, New Mexico. The Department of Energy provided funds for the test program and for a sodium loop. Sodium receivers and other advanced central receiver technologies hold the potential to keep the United States at the forefront of this technology, provided that a spirit of cooperation can be maintained between the manufacturers and the Department of Energy, and that the existing test facilities remain available for advanced subsystem test and evaluation.

Second-Generation Heliostat Testing

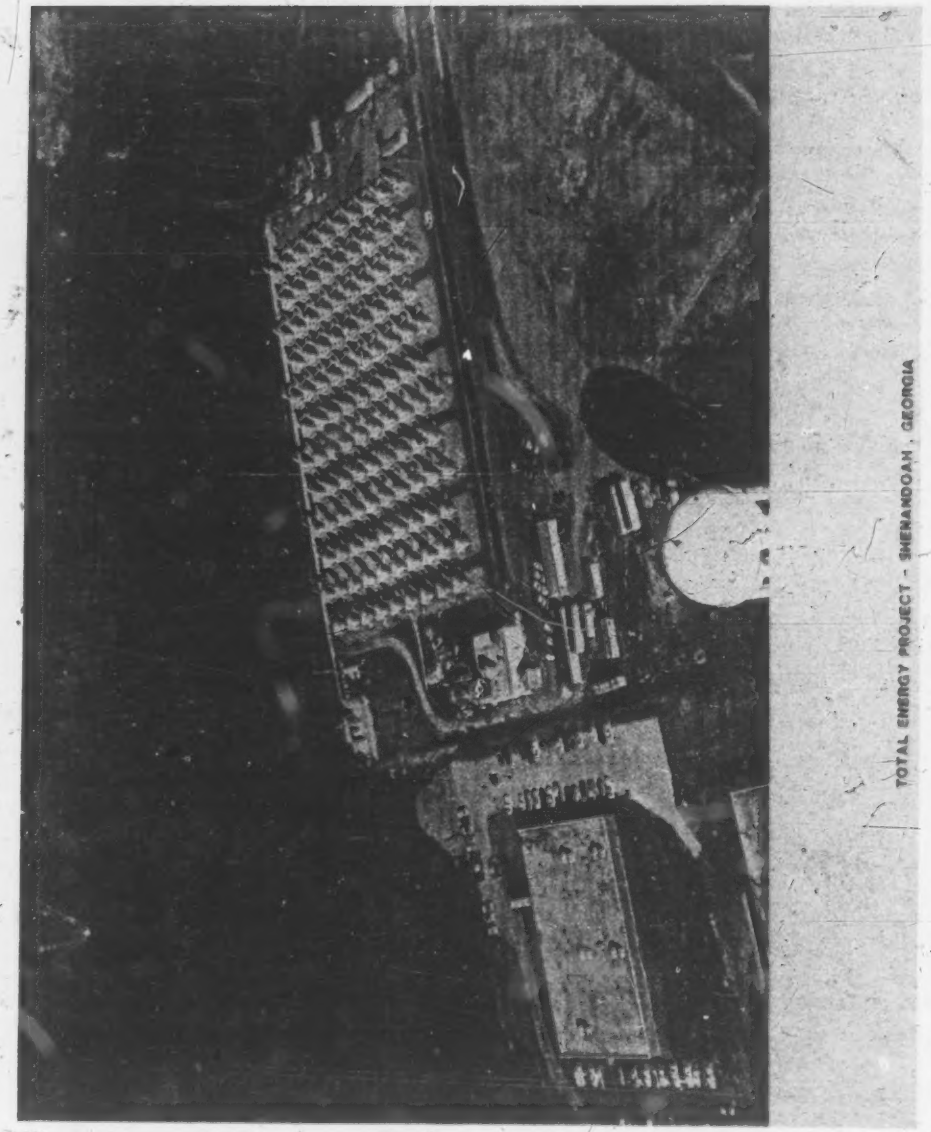
Four industrial firms designed and built second-generation heliostat prototypes which successfully completed test and evaluation at the Sandia National Laboratories. Significant operating parameters were demonstrated that met the 30-year life cycle design goal and the mass-produced cost goal of $\$100/m^2$ or less.

Shenandoah

The important cogeneration project at Shenandoah, Georgia is rapidly approaching dedication in April. This project is a major milestone for dish technology and will be invaluable for establishing cost and performance parameters for industrial process heat and cogeneration applications. The Shenandoah



SODRM RECEIVER TEST AT CENTRAL RECEIVER TEST FACILITY - ALBUQUERQUE, NM.



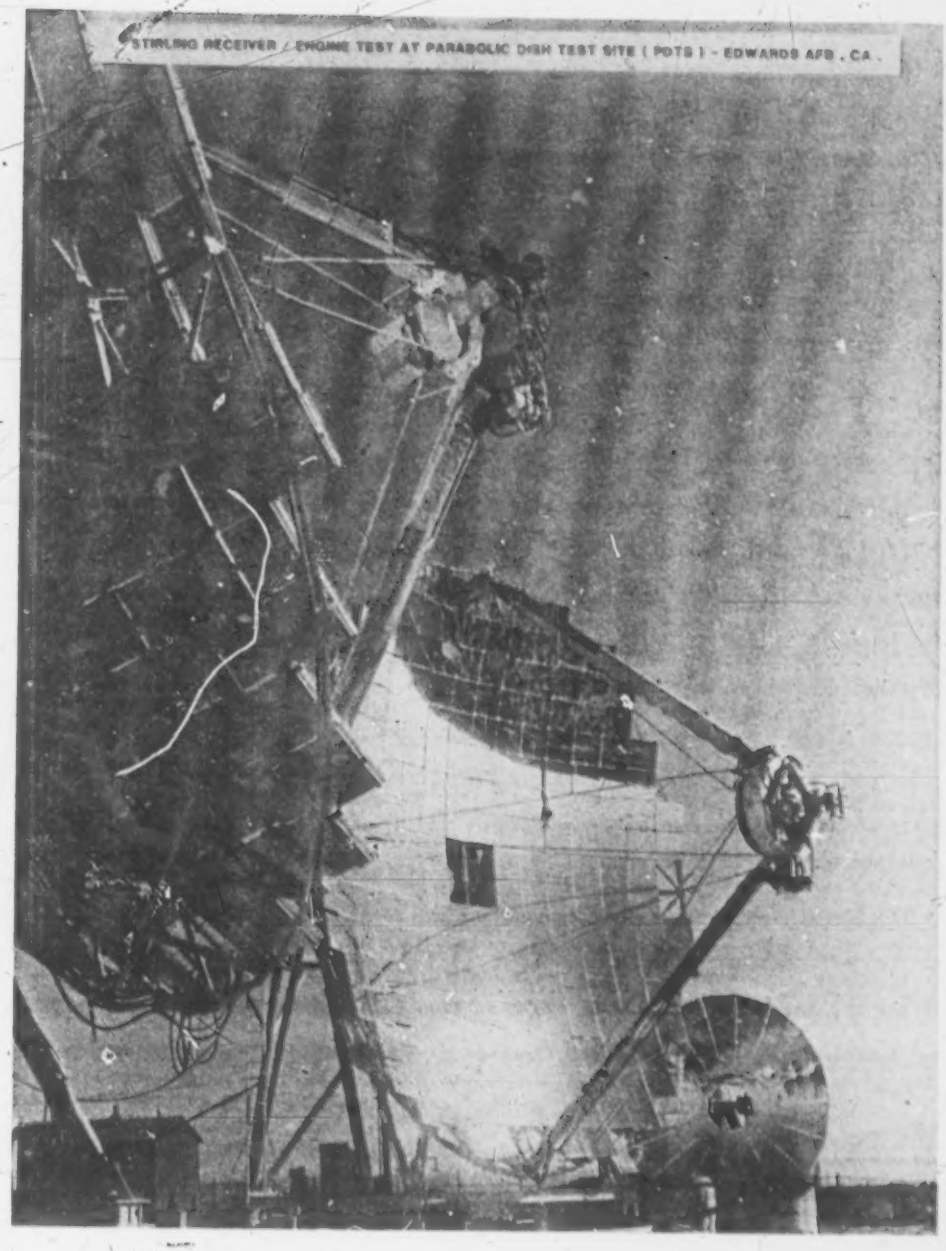
TOTAL ENERGY PROJECT - SHENANDOAH, GEORGIA

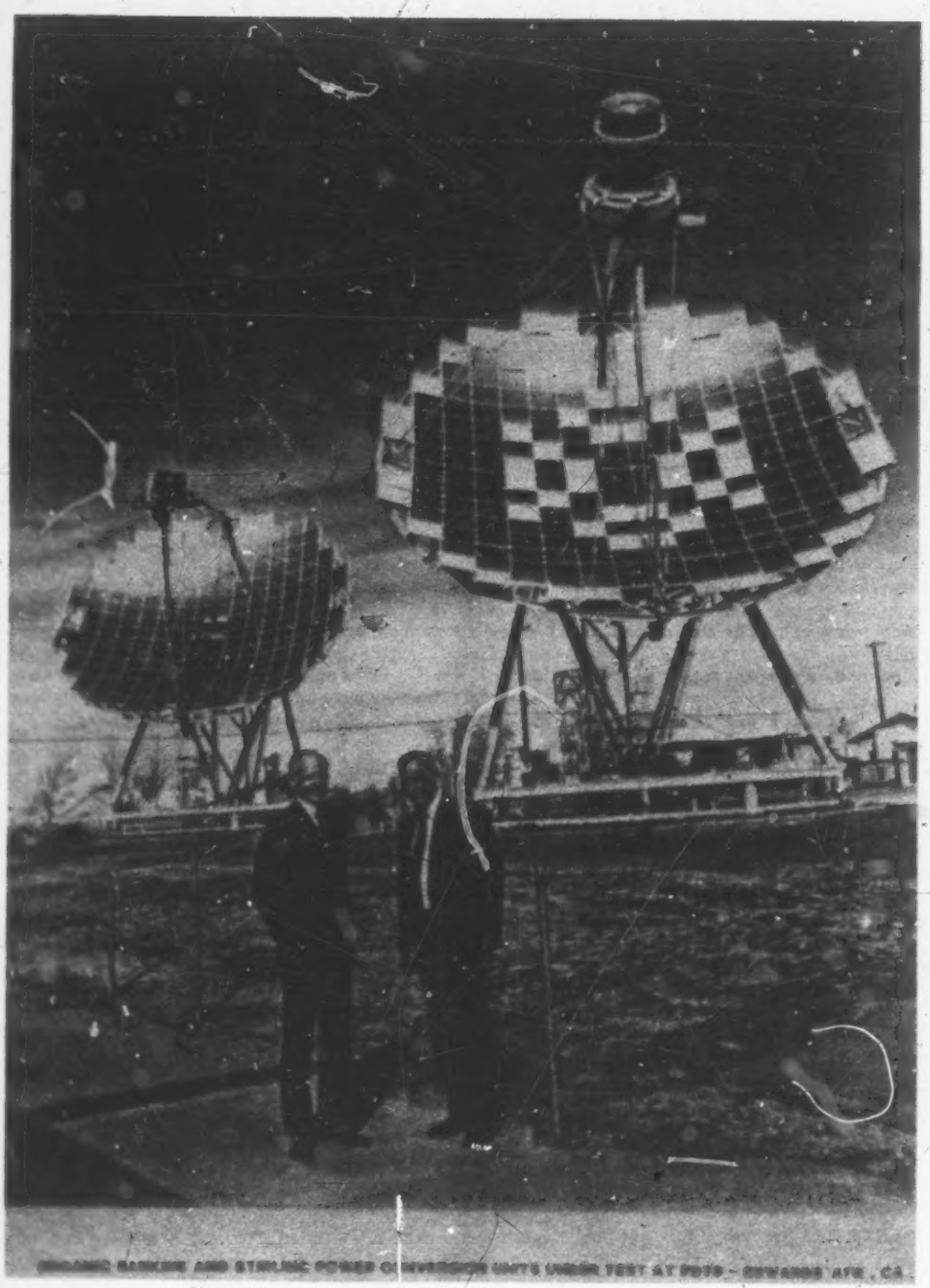
system is capable of supplying the adjacent knitwear factory with 100-400 KWe output with process steam extraction at 330°F for pressing fabric, and heating and cooling for 25,000 square foot of floor space. As with Solar I, the completion of Shenandoah illustrates the effectiveness of the Department of Energy in coordinating the work of many subsystem manufacturers.

The Shenandoah project is supported through a cost-shared agreement between the Department of Energy and the Georgia Power Company. Georgia Power has been designated as the Plant Operating Authority and will provide the operating staff and daily supervision and maintenance of the plant.

Simultaneous Dish-Electric Receiver and Engine Tests

The Department of Energy has been coordinating the development of Rankine, Stirling, and Brayton engine/receiver combinations capable of highly efficient and reliable electric generation from parabolic dishes. The Energy Research and Advisory Board (ERAB) report recommended that dish module development be continued and noted that high temperature collectors deserve "increased support because of their great versatility." The first power conversion unit to be successfully tested at the JPL Edwards Test Site was the hybrid dish Stirling receiver manufactured by Fairchild Stratos and using a United Stirling 4-95 engine in November 1981. Further testing in February 1982 with a 'solar only receiver' produced a record performance output of 22 kWe and sunlight to electricity efficiencies in excess of 27%! February also marked the first operation of the organic Rankine receiver from Ford Aerospace and Communications Corporation and a Barber-Nichols engine which achieved 17 kWe with an efficiency, of heat into the receiver to electricity out, of 21%. A Brayton engine and receiver are to be similarly tested in September 1982. This testing marks the first simultaneous testing of engine and receiver subassemblies under the program.


STIRLING RECEIVER / ENGINE TEST AT PARABOLIC DISH TEST SITE (PDTS) - EDWARDS AFB , CA .



ORGANIC RANKINE AND STIRLING POWER CONVERSION UNITS UNDER TEST AT PSTO - EDWARDS AFB , CA .

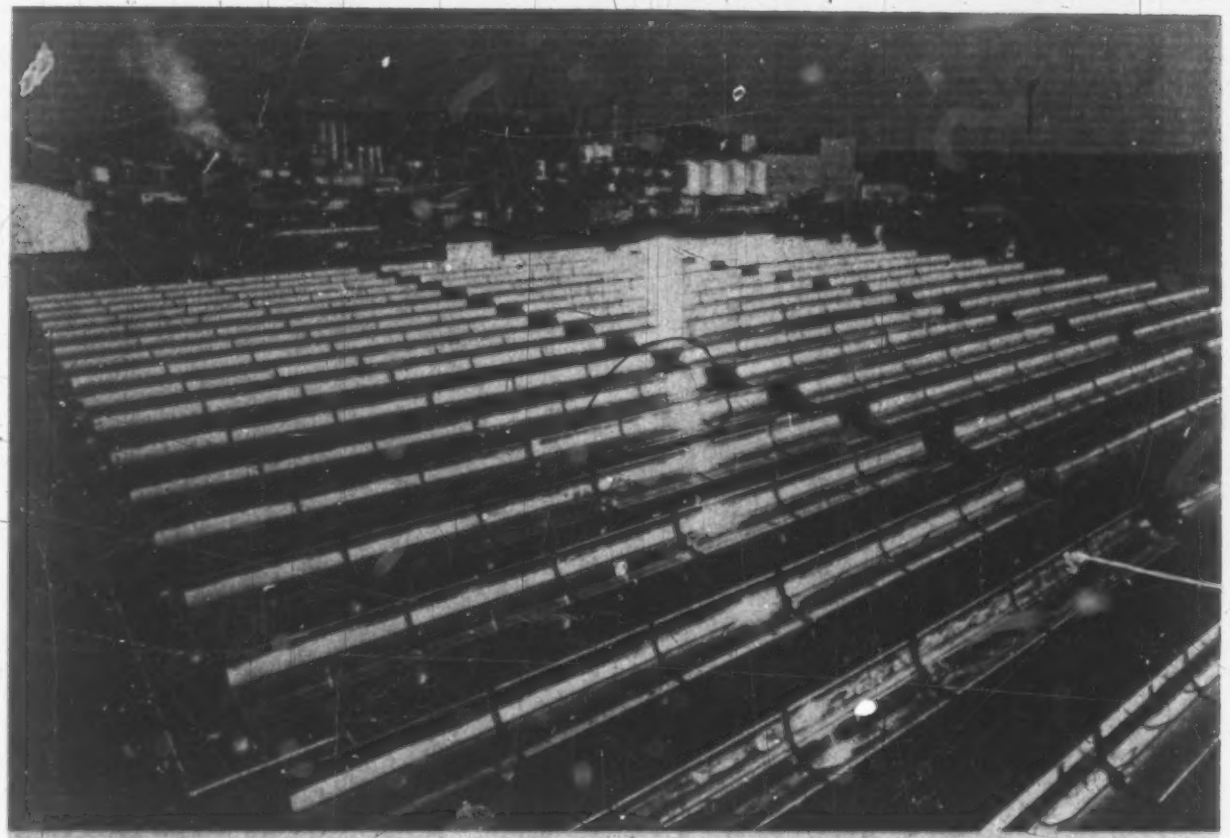
Hardware fabrication is continuing on the dish-Brayton engine and receiver. Two Brayton receivers are under development. Garrett AiResearch is developing an Inconel 625 receiver for applications up to 1500°F. Sanders Associates are designing a ceramic receiver for higher temperature applications. Both receivers are designed for efficiencies as high as 88%. The Brayton engine, manufactured by Garrett Turbine Engine Company, as an associated activity of the automotive gas turbine program is expected to have an efficiency of 30-40%.

Troughs

Parabolic troughs are the solar thermal technology with which we have the most experience and the greatest number of systems in operation. Over three quarters of a million square feet of collectors have been installed as a result of field test experiments, research and development projects and commercial sales. Several STEA members market troughs commercially while others continue to work with the Department of Energy in improving the technology. STEA members have cooperated with the Department of Energy on a number of highly successful industrial process heat installations using parabolic troughs. One recent installation is the United States Steel Chemicals plant in Haverhill, Ohio, which uses 50,400 ft^2 of troughs to provide process steam for polystyrene production.

In successive projects parabolic trough systems have demonstrated increasingly higher efficiencies, higher reliability and lower costs.

The Modular Industrial System Retrofit (MISR) program represents the final step of government support for parabolic troughs. Under MISR, five manufacturers are developing troughs which incorporate the latest advances in trough technology, which are mass producible, and which can be provided in modular units. MISR will validate the modular system design concept and provide an orderly and



INDUSTRIAL PROCESS HEAT PROJECT - HAVERHILL, OHIO

satisfactory conclusion to federally sponsored line-focus development. MISR testing is scheduled for the summer of this year.

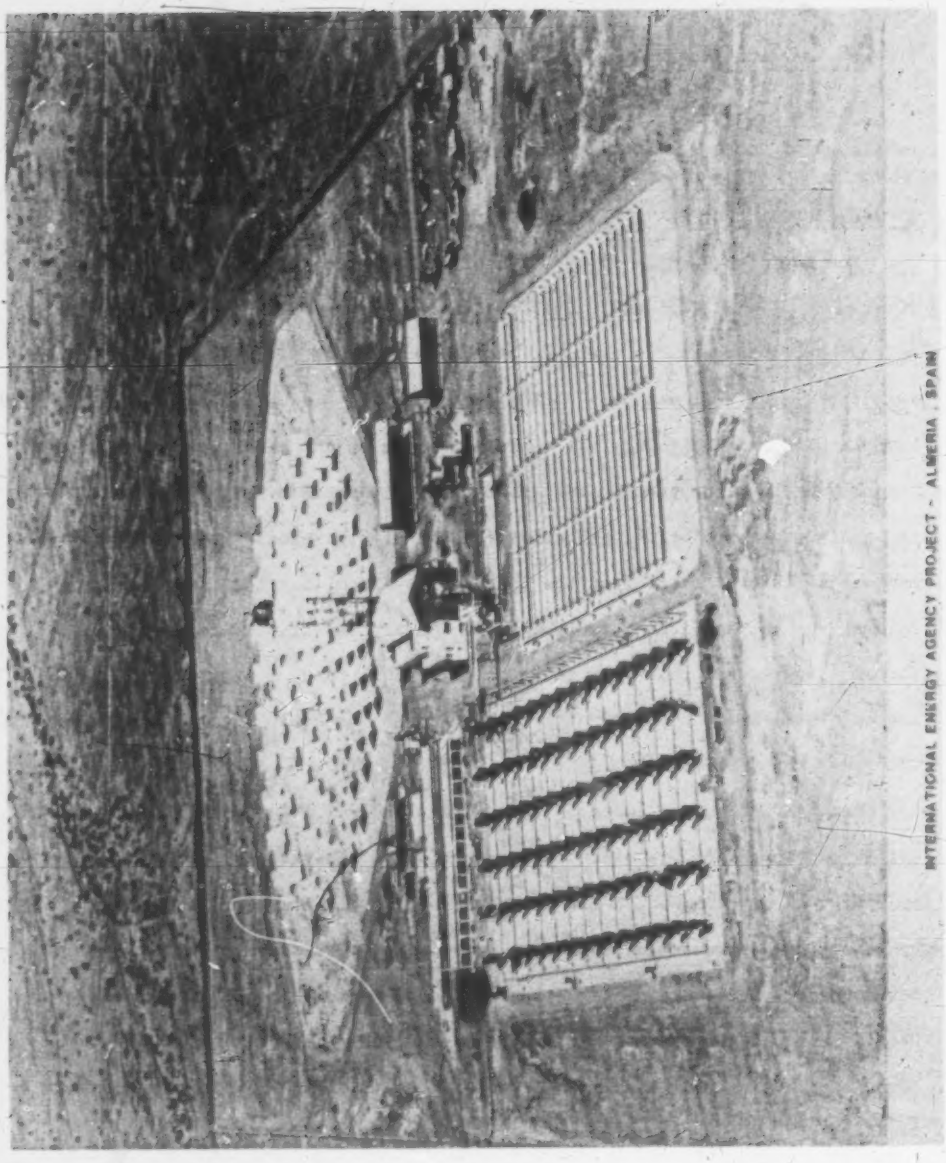
International Energy Agency

Outside the United States, STEA members and the Department of Energy are cooperating in a number of internationally sponsored solar thermal projects. The largest of these projects is the International Energy Agency (IEA) project in Almeria, Spain. In Almeria, two side-by-side 500 KWe solar thermal generating plants have been built. One of these plants utilizes a small central receiver design with Barstow-type heliostats and incorporates a sodium-cooled receiver. The other plant employs an array of parabolic trough concentrating collectors. The parabolic trough project is unique in that it is made up of two collector fields of equal size. One field contains German MAN collectors while the other collectors are from Acurex. The important role of the Department of Energy and Solar Thermal Energy Association members in international projects demonstrates America's leadership in and commitment to solar thermal energy.

RATIONALE FOR SOLAR THERMAL ENERGY

The preceding slides illustrated the direction that the Solar Thermal Program has taken in the past. The future direction of the program, and in a very real sense the future of the technology, is now being considered by this Committee as it examines the Department of Energy's FY 1983 budget request. We believe that the needs of solar thermal technology go beyond the "long-term research and development" that the Administration is stressing at the expense of all other approaches.

The need for solar thermal energy is even greater today than it was when Congress passed the Solar Energy Research Development and Demonstration Act of 1974. Solar thermal systems can provide reliable and cost competitive



INTERNATIONAL ENERGY AGENCY PROJECT - ALMERIA, SPAIN

energy. They can produce a broad range of energy products: electricity, process heat and fuels and chemicals. These are the forms of energy which our society is structured upon; solar thermal energy is capable of making an valuable contribution to our national energy mix.

FY 1983 BUDGET REQUEST

The Administration's FY 1983 budget request for Solar Thermal Technology Program is only $18,025,000. This figure represents only a fraction of the solar thermal budgets for the past two years. The total solar thermal budget authority in FY 1981 was over $138M; this year the Congress provided the Division of Solar Thermal Technology with nearly $55M in budget authority. For the second year in a row the Administration has formulated a budget request that is barely one-third of the preceding year's authorization. Last year, the members of this Committee and the Congress realized that the Administration request was not sufficient to meet the needs of the Solar Thermal Program. Industry hopes that this year this Committee will reach a similar conclusion and will take action to assure that the Division of Solar Thermal Technology receives a more realistic budget.

The Administration contends that future federal efforts should concentrate solely on "long-term high-risk research and development." By emphasizing basic research and development at the expense of virtually all other approaches, however, the Department of Energy has chosen the slowest route to technology development. In determining the appropriate budget for the Solar Thermal Program, this Committee must determine whether the purported thrust of the Administration's $18M budget -- long-term, high-risk R&D -- fits the current requirements of the technology.

The Solar Thermal Energy Association (STEA) considers the Administration's budget request inadequate. Appended to my remarks is a comprehensive alternative

budget that totals $59.5M. We at STEA have spelled out our rationale for each line item and we feel that our submission represents a realistic and balanced approach to the development requirements of solar thermal energy. For some technologies the $41.5M difference between our budget and the Administration's request may well mean the difference between a viable solar thermal industry, in this country, in the next several years and no solar thermal industry at all.

IMPORTANT QUESTIONS

It is incumbent upon this Committee to consider three questions as it formulates the FY 1983 solar budget for the Department of Energy. The first is whether the Administration's policy has been applied evenly to all energy technologies. The answer to this is clearly no; the Administration has only sought to limit the federal presence in energy development and to rely on private initiatives in those energy technologies that it does not support.

The second question is whether a single economic or technical development has altered the long-term need for alternative sources of energy. Again, the answer is no. The need for solar and other forms of alternative energy is just as real today as it was in 1974 when the government embarked on the current development effort. The only change has been a philosophical one on the part of the Administration.

The final question is how will history judge us. If more support is not provided for solar thermal technologies, the answer will likely be "short-sighted." Right now oil prices are stabilizing, but we cannot allow ourselves to slip into complacency. Rather, we must learn from history. This is the best time to be pursuing alternative energy options and broadening our energy base. The U.S. is still heavily dependent on foreign oil. The amount that this country pays for eight hours of oil imports - $41M - could mean the difference between a vigorous Solar Thermal Program and a program that has been virtually phased-out.

GOVERNMENT AND INDUSTRY

The Solar Thermal Energy Association supports the efforts of the President and the Congress to reduce the size of the federal government. The close relationship between government expenditures on solar thermal energy and the development of the technology within the private sector, however, requires STEA to make several points.

The solar thermal budget should help maintain the momentum that exists within the private sector for solar energy research, development and demonstration by offering industry the prospects of economic rewards within a reasonable time. Budget reductions for solar thermal system applications and experiments will result in the premature elimination of one or more promising technologies. The solar thermal technologies are currently on parallel development paths and sufficient data does not exist to justify the elimination of any candidate systems.

Large segments of the solar thermal industry are prepared to optimize the effect that federal funds have on solar thermal research, development and demonstration through cooperative and innovative financing arrangements. The use of cooperative agreements, contingent liability agreements and third party financing techniques will minimize the requirements on the federal budget while assuring the development of a technical and economic base for solar thermal energy's contribution to the national energy supply.

Within the industrial sector a concensus exists that private industry should continue to have access to the expertise that has been developed at the National Laboratories over the past five years. Without sufficient funding, the Solar Thermal Program will be unable to keep the teams that have worked with the technology intact. This lack of continuity would bring technology transfer from government to industry to a halt and would make it impossible to reap the full benefits of past solar thermal research and development

efforts. If the Administration succeeds in its attempt to transfer most solar thermal R&D to the private sector, future research will likely result in the duplication of proprietary efforts. This Balkanization of solar thermal research and development efforts will harm industry and will eliminate the spirit of cooperation that accompanied the development of the technology for the past five years.

The Solar Energy Industries Association supports efforts to control federal spending, but if the full potential of solar thermal energy is to be reached before the end of this century, federal policies must favor solar energy. SEIA supports the search for the combination of federal expenditures and tax and institutional policies that will minimize the pressure on the federal budget while maximizing U.S. industrial output in solar thermal energy. As businessmen, we are willing to work with the Administration and the Congress to develop and participate in cost-shared programs that are responsive to competitive market forces and result in operable systems.

THE THREATS TO SOLAR THERMAL

As I am sure the members of this Committee are aware, solar energy is currently under siege in this country. Just as solar technologies are approaching viability they are being threatened with termination.

From the perspective of the solar thermal industry, the Administration's budget for the Division of Solar Thermal Technology is only one of three threats that we face this year. Perhaps as important as the FY 1983 budget to the future of solar thermal technology, is the proposed elimination of business energy tax credits and the Public Utility Regulatory Policies Act (PURPA) modifications that may be required. The uncertainty surrounding these policies clouds the future of solar thermal systems and makes potential investors very wary. Both the business energy tax credits and the existence of PURPA provide manufacturers

with predictable markets and ensure that the technology will be able to enter the marketplace.

The administration has consistently relied upon the range of existing energy tax credits to support the reduction of renewable energy R&D funds. The elimination of business tax credits would deny solar thermal manufacturers effective access to a major sector of the energy market. Appended to my remarks is a short explanation of the need to retain all energy tax credits.

Electric generation is a future solar thermal market, which is why STEA is also concerned with the uncertainty regarding PURPA. The recent court decision vacated two essential elements of the Federal Energy Regulatory Commission's implementation of PURPA. The long-term (20-year) payback of these ventures requires investors to be sure that a reliable market exists before they offer their support. While various solutions to the PURPA dilemma are pending, I want this Committee to be aware of the environment of extreme uncertainty in which solar thermal manufacturers are currently operating.

THE SOLAR THERMAL INDUSTRY

The solar thermal industry in this country is diverse and growing. The Solar Thermal Energy Association includes manufacturers from all over the country. Our members produce solar thermal components and subsystems such as solar collectors, solar receivers, heat exchangers and power conversion modules. As I noted earlier, complete solar thermal plants require the efforts of a wide variety of solar thermal manufacturers.

The complex nature of complete solar thermal systems is the main reason that the government should have such an important role in the development of the technology. The solar thermal industry has shown itself willing to take risks incident to the normal operation of businesses. Individual manufacturers, however, are incapable of assuming all the risks inherent in forming a single system from

a range of components and subsystems. A single integrator is required to pull together the elements of a solar thermal systems and take responsiblity for system-wide risks.

GOVERNMENT'S ROLE AS INTEGRATOR

In the development of solar thermal technology, the federal government has assumed the role of systems integrator. Solar thermal systems rely on many existing industrial skills but no single manufacturer or single industry will ever manufacture, test and market entire solar thermal systems. As a result no one industry or manufacturer is presently capable of taking the risk of complete solar thermal systems R&D. The skills and interests of individual manufacturers, even solar thermal manufacturers, are too narrow to allow them to assume the risks associated with an entire system. Until now, the need for alternative sources of energy, has allowed the federal government to use its resources to bring together the elements of solar thermal systems.

As you saw earlier, the result of government efforts to date has been impressive. The most important part of the development effort, however, remains before us. Considerable risk exists in the construction of systems, but it is much more important to resolve the uncertainties associated with system operation. This is the information that will convince system users who in turn, will generate a market for solar thermal systems.

A recent article in the Electric Power Research Institute (EPRI) Journal, which is appended to my remarks, indicated that utility interest in solar thermal energy is at an all time high but noted that performance information and operating experience are necessary prerequisites to solar thermal systems becoming a commercial reality. It is incumbent upon the federal government to quantify the unknowns that exist with regard to solar thermal systems. Of prime importance is the verification of overall system efficiencies, the docu-

mentation of operation and maintenance requirements and the establishment of system reliability. The solar thermal industry is too diffuse to perform these investigations but will benefit from the benchmarks that these data will provide.

PRIVATE INDUSTRY CAN CONTINUE THE WORK

The dissemination of this information will inspire user confidence in solar thermal systems and will reduce the risks faced by industry to an acceptable level. Market mechanisms will be able to take over at this point and the solar thermal industry will be able to make final system improvements and finalize production designs.

Once system-wide risks have been reduced, the remaining uncertainties will be within the sphere of normal business operations. Individual solar thermal manfacturers will be in a position to assess their markets and secure financing. In my own experience, the questions I am being asked by investment bankers concern proven system efficiencies and overall operation and maintenance costs. Only when these sorts of issues, which are beyond the scope of individual manufacturers, are resolved, will we begin to see a viable solar thermal industry emerge in this country.

CONCLUSION

Mr. Chairman, today I have shown this Committee the "proof positive" technical dividends of the federal investment in solar thermal technology. They indicate that the government/industry partnership is producing new industries with a future capability of competing on an economically viable basis. As our envelope of risk is reduced, the need for federal budgetary support will commensurately reduce. We have demonstrated this to be true in the parabolic trough industry. Industry is increasing its private investment in these solar thermal technologies by advocating cost-sharing cooperative agreements, contingency liability agreements

and similar instruments to increase the value of the federal resources that are available in FY 1983 and in the out years. American industry believes that such efforts should represent a standard by which all projects and technologies are judged. The level of partnership requested of the federal government is $59.5M which is $41.5M above administration request. This difference is equal to eight hours of foreign oil purchases but equates to whether or not there will be a solar thermal industry to provide renewable energy and a new source of employment to this nation.

The Treasury Department's proposed repeal of the 15% business energy tax credit will eliminate this young industry's ability to continue the technology development on a cost-shared basis and to raise the venture capital or third party financing necessary for the initial commercial projects. The Treasury proposes this repeal in the face of a resolution co-authored by 62 senators and 262 congressmen opposing such a move. Finally, Treasury's own analysis states that, "over 90% of this gain [increased federal revenue] will result from credits for biomass equipment and low-head hydroelectric projects." Industry asks that every member of Congress stand firmly against repeal of the business energy tax credit.

The American public continues to support the ethics of renewable energy technology as a part of the energy supply mix. A Gallup poll conducted during the 1980 Presidential election period identifies renewable energy as the most preferred choice of the American public, while only 3% characterized it as least preferred. Let us continue the government/industry partnership to assure that solar energy makes the national energy contribution that we all envision.

We appreciate this opportunity to offer American industry's position to the Energy Development and Application Subcommittee.

APPENDIX A

SOLAR THERMAL ENERGY ASSOCIATION (STEA)
PROPOSED FY 1983 SOLAR THERMAL BUDGET
(dollars in millions)

Item No.	Project	Technology Category: Research	Energy Technology	System Application	Planning and Control	
1	Solar I			10.0		
2	Repowering			15.0		
3	Small Community Project (Dish Program)			3.0		
4	Brayton Module Development (Dish Program)		2.5			
5	Research Facilities	4.8				
6	Receiver Development		3.3			
7	Steam Generator Development		2.8			
8	Dish Research	2.5				
9	Shenandoah			1.5		
10	Storage Concept Development			1.6		
11	Concentrator Development (Dish Program)		2.0			
12	Trough Materials		1.0			
13	University Research	1.0				
14	Trough Operations			2.0		
15	Parabolic Dish Hybrid Receivers		1.0			
16	Technology Utilization		1.0			
17	Heliostat Development		1.0			
18	Sunfuels	1.3				
19	SERI Capital Equipment	0.2				
20	Planning and Coordinating				1.5	
21	Salt Pond Research	0.5				
		10.3	14.6	33.1	1.5	
	GRAND TOTAL					59.9

Total Central Receiver = 36.7

Total Parabolic Dish = 14.3

Total Parabolic Trough = 3.0

Total Other = 5.5

59.5

STEA FY 1983 BUDGET JUSTIFICATION

1. Solar I

The operation of Solar I is a crucial step in the development of the central receiver concept and in getting the technology transferred to the private sector. Most, if not all, of the prospective users (see Utility Position Paper dated October 30, 1981) have indicated that Solar I is needed to convince the utility management that the generic concept can meet performance, cost, operating, and durability goals. The industry feels that $10 million is a realistic budget number considering the actual tasks that arise when starting up and operating a first-of-a-kind power system.

2. Repowering

The solar industry feels that the central receiver is close to, but not yet at, the point at which it can be turned over to the private sector. There exists three principle technical/cost barriers to its acceptance. One of these is an uncertainty, of at least 50%, in the cost of central receivers of the types and sizes that will be needed to fill the intermediate demand market (greater than 30 MWe and all-liquid-type coolants). This uncertainty appears at this time to be one of the barriers preventing its introduction into the market place either via direct utility financing, or via other user financing, or via third party venture approaches. A very important step in eliminating this uncertainty is to support, in conjunction with significant cost sharing on the part of the private sector, a preliminary design of at least two solar power plants (either two repowering, two standalone, or one of each). Since there is a reasonably reliable estimate of the cost of preliminary design efforts relative to the estimated capital cost of a project, a budget of $15 million is being recommended for the repowering effort by industry.

3. Small Community Project

DOE has selected six geographically distributed, small communities as candidates for a 150-kW solar thermal experiment. Continued federal budget constraints have reduced this project to the minimum acceptable size and jeopardized the project due to out-year funding requirements. Industry advocates the authorization of $3 million to be equally divided amongst the interested sites. The sites will, in turn, contract directly with the parabolic dish industry to install and operate the maximum number possible of experimental modules by leveraging the limited federal funds with available venture capital. This approach results in no out-year budget requests, a significantly greater level of experimentation with multiple design approaches, and the use of preimarily of venture capital rather than federal funds.

4. Parabolic Dish Brayton Module Development

The Brayton module development represents a team of industrial contractors attempting to design, manufacture, and test a fully integrated parabolic Brayton module. Industry views with great concern that DOE's FY 1982 expenditures for

this program are only $0.7 million with over $2 million appropriated for closing out the parabolic dish program. FY 1983 requests are $2.5 million, with the belief that DOE will reevaluate the FY 1982 funding deficiencies. No out-year federal funds would be requested for the Brayton module development.

5. Research Facilities

The solar industry is strongly convinced that solar research facilities are essential to the development of solar energy. The very nature of the solar source, its frequency distribution; its diffuse nature; its variability with time, location, and weather conditions; its diurnal nature, etc., dictate that solar energy concepts, whether long term or short term, high risk or low risk, or involving high- or low-payoff potential, be verified under real solar conditions. The ability to transfer the technology to the private sector at any time will depend to some extent on the degree to which the technical feasibility of the process or component has been verified at a real solar source. In addition, private industry anticipates a need to have facilities available at which testing can be conducted on hardware designed and fabricated by private industry. Any given private organization could not afford or justify keeping a facility active on the basis of the infrequent times at which its own needs must be met. Industry feels, therefore, that this need should logically be met by federal involvement. Of the $4.8 million recommended for this activity, $3 million is needed at the Central Receiver Research Facility in Albuquerque, New Mexico. About $1 million is needed for use by the Solar Thermal Test Facilities Users Association in supporting work at the Advanced Component Test Facility at the Georgia Institute of Technology, at the White Sands Solar Furnace near Las Cruces, New Mexico, and at the Test Bed Concentrators at Edwards Air Force Base. Also, a separate allocation of $0.8 million is recommended specifically for testing of parabolic dish systems on the Test Bed Concentrators at Edwards Air Force Base.

6. Receiver

Of the three barriers impeding the introduction of the central receiver technology into the private sector mentioned above, the second one pertains to performance uncertainties on certain key components.* Both the user industry and the third-party-venture capitalists have expressed concern about the fact that one of these key components, in particular, does not have a counterpart

*The third barrier, which involves the fact that the cost of the first five plants exceeds their value in the free market environment relative to fossil and other energy systems, can potentially be solved by means of the energy tax credit and third-party approaches. Thus, the industry feels that it is essential that the current cutoff date for the 15% energy tax credit be extended from December 1985 to mid-1995. Heliostat production, via the third-part-venture approach, will, by then, be sufficiently high to make the capital cost competitive with fossil systems in the free market environment.

in current industrial practice. This component is the receiver located on top of the tower. In order to remove this barrier and to reduce the perceived risk on this component to the point at which the private sector can pick it up and develop the component for commercialization, the industry recommends a base technology program which includes the receiver as well as two other key components on which industry feels there is undue risk in private-sector development. Insofar as the receiver is concerned, a FY 1983 budget of $3.3 million is considered necessary and should be applied to both the sodium- and salt-cooled concepts. Out-year budget recommendations are $4.1 million for FY 1984 and $3 million for FY 1985. All technology development should be terminated at that point, and no further federal involvement in this area would be considered necessary.

7. Steam Generator

The second key component is the steam generator. Although both sodium and salt steam generators have been built and are at very different stages of development in the U.S., there are certain unique features that are required for the solar application that makes them fall outside of the capability of private-sector development. One of these is the use of the steam generator in the reheater mode. Currently, there are no U.S. manufacturers of steam generators for this application. Another one is that the nominal operating temperatures are considerably higher in the solar application than those that have been used in industry. These factors have led to a recommendation for a FY 1983 budget of $2.8 million, most of which would address salt steam generator development, but some of which would be needed for the sodium system. Out-year budget values would be $4 million and $1.1 million for FYs 1984 and 1985, respectively, with termination at the end of FY 1985.

8. Parabolic Dish Applied Research

A FY 1983 request of $2.5 million in three applied research areas in the parabolic dish program is advocated by industry. The three areas are all high risk and high payoff with generic application to all future parabolic dish technology. The three areas include: (1) ceramic material and manufacturing techniques for high-temperature receivers, (2) improved reflective surfaces, and (3) low-cost system level controls.

9. Shenandoah

Industry feels that a $1.5 million expenditure to complete this project is essential in providing the user community with confidence that the generic dish concept can be operated effectively.

10. Storage

The third component that impedes the acceptance of the central receiver in the longer term is a storage concept that is low in cost and economically viable beyond 12 to 18 h. Conceptual feasibility of at least one thermal energy storage system meeting these criteria has been identified and analyzed. However, technical

feasibility needs to be demonstrated before the private sector can take over its engineering development. The design, fabrication, test, and analysis of a test article of sufficient size to verify development potential is estimated at $1.6 million for FY 1983, $0.6 million for FY 1984, and $0.4 million for FY 1985. No funding beyond that time is considered justified. Further development would fall within the private sector.

11. Parabolic Dish Concentrator Development

Significant advancement is required in the parabolic dish concentrator to achieve low cost and long life. The second-generation heliostat study produced significant advancements in the central receiver technology, and it is felt that similar results are possible here if undertaken. In FY 1983, $2 million is requested for this program that would have two or more competitive design efforts.

12. Trough Materials

STEA recommends materials research in the amount of $1 million. Research funds are recommended in order to develop improved absorbers, reflectors, etc. Examples of the types of activities that would be supported are: research on antireflective glazings, lower cost reflectors produced by techniques such as sputtering, and effective absorbers other than black chrome.

13. University Research

Research work carried out by U.S. universities has been useful in the past in identifying promising concepts and processes in solar thermal technology. The industry feels that such work should be continued in FY 1983 and beyond at or near the $1 million level in 1983 dollars. In the view of industry, this research should have a very general goal of identifying, analyzing and carrying out laboratory scale and test facility experiments on processes that can potentially have a significant impact on energy independence, stabilization of energy prices, and reduction of energy imports.

14. Trough Operations

STEA recommends data aquisition and continued operation of existing systems at a $2 million level. It is in the best interest of the line focus industry and the Government that existing federally funded systems be operated long enough to obtain useful data on system performance, degradation with time, reliability, maintainability, etc. Funds are required in FY 1983 to insure that systems which have recently come on line or have recently been upgraded will be operated for a sufficient period to permit useful data to be obtained so as to justify the investment of federal funds in the project.

15. Parabolic Dish Hybrid Receivers

Preliminary results from design experiments of hybrid receivers using natural gas fuel have indicated favorable capacity and operational performances for

parabolic dish systems. The more difficult technical development of using low-cost fuels other than natural gas is now required to fully implement this hybrid opportunity in future parabolic dish systems. FY 1983 requests are $1 million.

16. Technology Utilization

Industry encourages DOE to become fully aware of the applicable heat engine and materials research being conducted by DOD. It is felt that the data available from these DOD programs can be applied to the solar programs and that DOE should cooperatively work with DOD to structure and fund these programs accordingly. FY 1983 requests are $1 million.

17. Heliostats

A fourth component for which a small amount of additional R&D is required in order to transfer the technology to the private sector is the glass-type heliostat. Among other technical issues, the adequacy of the seal between the reflective glass element and its backing remains in serious question. The industry recommends a budget of $1 million for FY 1983 to address this issue as well as several others which must be resolved in order to convince the user sector that long lifetime is achieveable for heliostats. No out-year budget needs in this category are expected.

18. Sunfuels

Although the solar thermal industry recommends that R&D in the area of the application of solar thermal processes to the production of fuels and chemicals be conducted, we do not feel that it should have a high priority since it cannot have a near-term impact on stabilization of energy prices or on energy independence. We do feel, however, that a $1.3 million effort is justified, provided it is expanded on research on processes and systems that can potentially apply to a broad range of current industrial processes and products. Even though, for example, a long-term goal of producing hydrogen by means of thermochemical processes appears to be promising, that goal should be reached via analyses, research, and development which can be of use to the U.S. industry in the near term. The industry feels that funding for research and development in the field of fuels and chemicals should be kept at a low level until the nearer-term technology development applying to the parabolic dish, central receivers, and parabolic troughs is at a stage at which it can and will be picked up by the private sector for commercialization. Out-year budgets for sunfuels are, therefore, recommended for increases consistent with the potential impact that the fuels and chemicals systems can have on the U.S. energy situation.

19. SERI Capital Equipment

The solar thermal industry recommends an expenditure of about $0.2 million for use by the Solar Energy Research Institute for the purchase of instruments and peripheral equipment in order to support materials testing on solar thermal systems.

20. Planning and Coordination

Approximately $1.5 million is recommended by the industry for allocation in the area of planning and and coordination of solar thermal activities. These activities should be directed toward all technologies, with emphasis on longer-term activities. The industry opposes activities dealing with cost goals, since such activities tend to have a negative effect on private-sector marketing activities.

21. Salt Pond Research

The solar thermal industry feels that research and development on solar pond concepts, although they can potentially lead to a technology that might have a significant impact on the U.S. energy situation, should be funded at a low level of the order of $0.5 million for FY 1983 and should then increase in out-years consistent with the potential predicted by the early R&D. In part, this recommendation is based upon a recognition of the fact that funding resources on the part of the Federal Government are now and will be limited for the near future, and that we feel that other technologies, further along toward feasibility, should be gotten into the private sector first.

APPENDIX B

THE NEED TO RETAIN THE RENEWABLE ENERGY AND CONSERVATION TAX CREDITS OF PRESENT LAW

October 12, 1981

Prepared by
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For the Solar Thermal Division of the
Solar Energy Industries Association

Executive Summary and Conclusions

1. Repeal of the renewable energy and conservation tax credits, particularly in combination with the massive budget cutbacks in the supporting programs in the Department of Energy, would result in the curtailment of a large number of projects, impede the timely development and expansion of the renewable energy and conservation industries, and result in damage to the economy by reductions in employment and exports.

2. The renewable energy and conservation industries represent a strategic infant sector of the economy. Even with present Government tax subsidies, this sector opetates at an economic disadvantage with respect to both conventional domestic energy sources and foreign renewable energy and conservation competitors.

3. There has been no change in the circumstances that led to enactment of the credits in 1978 and 1980 such that the basis for their retention has been invalidated. The credits were passed because of a detrimental national dependence on imported energy. This dependence has not been significantly altered. Oil decontrol, the planned decontrol of natural gas, the establishment of the Strategic Petroleum Reserve, and emergency petroleum allocation regulations, do not reduce the need for fostering a renewable energy industry. Increases in oil and gas prices alone have not produced growth in the renewable energy and conservation market. Moreover, it is not reasonable to expect an infant industry to compete on a free market basis with an international cartel with the power to set prices at rates which will make market penetration of new products financially unsound. The Strategic Petroleum Reserve and emergency allocation regulations solve only short term management problems following import restrictions. They fail to address long term supply issues.

4. The replacement of the ADR depreciation system with the Accelerated Cost Recovery System (ACRS) will not increase the return on renewable energy investments. Also, while the new credit for incremental research and development expenditures is of some use, it is more important at this point to generate sales and production based on current technology. Moreover, because the renewable energy industry has already invested so heavily to reach the production stage, incremental expenses may be small.

5. Investors are willing to put their capital into a venture because of the expectation of profit. The greater the risk presented by a particular venture, the greater margin of profit the investor will require before it is willing to

make an investment. At the present time, investments in renewable energy and conservation projects tend to be of a high risk nature compared to other types of investments. As a result, they do not generally, standing alone, present investors with a sufficient margin of profit to attract the needed investment. The tax credits, in many cases, provide an additional margin of profit to eliminate this insufficiency.

6. The repeal of some or all of the renewable energy tax credits may not result in the net revenue gains predicted by the Treasury after economic (e.g., employment) consequences are taken into account.

7. The Administration's previous statements supporting the credits, reliance on their continued existence as a basis for Department of Energy cutbacks, and explicit Administration recognition that the credits are effective, are inconsistent with proposals to repeal some or all of the credits. Reliance on Administration statements led to support by companies for the Administration's economic program.

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APPENDIX C
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Solar-Thermal Electric: Focal Point for the Desert Sun

Power towers are now being raised in several countries, but the Solar One project in the California desert is perhaps the most critical milestone on the path to commercialization. Information flowing from this 10-MW working laboratory will assist in modifying future designs and provide sound data for evaluating performance and cost. With the benefits of mass production, it now appears that these systems for converting concentrated sunlight to electricity could become competitive with oil- and gas-fired plants in the American Southwest. If research momentum can be sustained, demonstration plants could be on-line by the end of the decade.

Bank upon bank of mirrors move slowly under the southern California sky, tracking the sun and concentrating its radiation on the receiver of a power tower nearby. Jutting 310 ft (94.5 m) above the desert floor, the tower looks a little like a rocket awaiting liftoff.

In a sense, the Solar One pilot plant, a joint DOE-utility project located in the Mojave Desert near Barstow, California, is a launchpad, but not for extraterrestrial travel. As the first U.S. 10-MW (e) solar-thermal pilot plant, it might well become the critical milestone for a joint industry-government commitment to the solar-thermal central receiver concept.

As Gerald Braun, director of DOE's Solar-Thermal Technology Division, has noted, the planned turbine roll at Solar One early in 1982, the first test of its electric output, represents a major event in efforts to advance this new technology to the point of commercial development.

Robert Hughey, director of DOE's Solar Energy Division office in San Francisco, adds that of all the solar-thermal conversion concepts, central receiver plants hold the greatest potential for electric utility applications. DOE and EPRI studies show that if carried through the test and demonstration cycles, solar-thermal central receiver power plants may be competitive in the Southwest with gas- and oil-fired plants.

"Of all the direct solar options under consideration by electric utilities today," says John Bigger, EPRI's solar-thermal project manager, "the prospects for solar-thermal conversion look the best." He adds that the most recent EPRI survey indicates that U.S. electric utility interest in solar-thermal energy is greater today than ever before, with utility support and participation in 68 solar-thermal projects this year.

What are the vital steps that remain to be taken for solar-thermal conversion to move from a promising prospect to an operating, commercial reality? Bigger sees two key steps: performance demonstrations and corporate commitments. "Pilot plants, like the Solar One project and five other central receiver tests starting up in Western Europe and Japan this year and next, are expected to contribute performance information and operating experience to encourage supply industries and electric utilities to make commitments to this emerging technology," says Bigger. This information and experience is needed to confirm the estimates of cost and performance made in earlier studies. Corporate commitments are needed to foster mass production, and hence economies of scale, in the construction of key components, such as heliostats (the mechanical tracking mirrors that reflect and concentrate solar energy).

A working laboratory

Deserts make ideal locations for solar-thermal conversion plants not only because the sunshine is abundant, which is critical, but also because land is relatively inexpensive and available. The Solar One site comprises 130 acres at Daggett, California, about 12 miles southeast of Barstow, California. It is owned by Southern California Edison Co., a sponsor of the project with DOE and the Los Angeles Department of Water & Power, the nation's largest municipal utility. The California Energy Commission is also a participant. In addition to providing the site, SCE joined LADWP in designing and building the steam turbine generator and other conventional components of the plant at a cost of about $21.5 million. McDonnell Douglas Corp. and Martin Marietta Corp. are the major contractors.

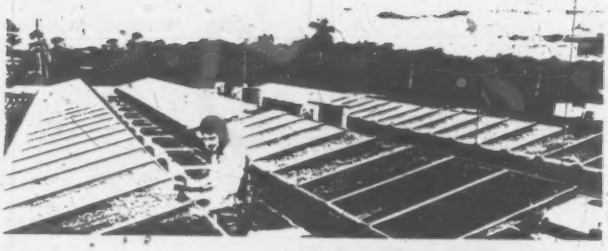
Solar One's start of operation is planned for mid-1982. The first two years of operation will include experimental testing of the major subsystems and evaluation of the operation and maintenance costs and requirements. This period will be followed by power production tests, which are designed to obtain longer-term operating, maintenance, and reliability data. The intent is to make more accurate estimates of commercial solar-thermal plant costs and performance.

When operating, the plant will use 1818 heliostats, each containing 12 separate mirror facets. Preprogrammed coordinates will be used to allow the heliostats to automatically track the position of the sun across the sky. The concentrated beam of solar energy reflected from the heliostats will be aimed at the central receiver on top of the structural steel tower. The energy focused on the central receiver will convert water to steam to operate a conventional turbine generator, producing up to 10 MW of electricity, the amount of power needed to supply a community of 7000–10,000. At night or during periods of high winds, the heliostats will be moved to the stow position horizontal to the ground, with the reflecting surfaces facing downward.

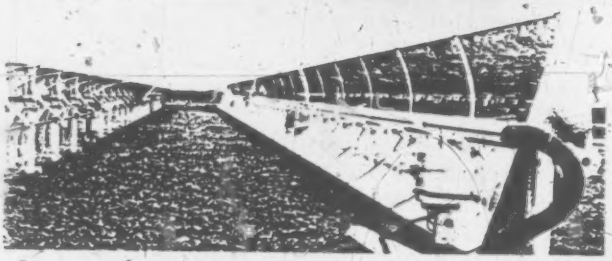
Solar One will serve as a laboratory, providing information on which many future decisions will be based. Information on equipment reliability and failure, for example, will be coupled with system performance data. These data will be vital to the decision makers planning and designing the next solar central receiver installations, perhaps in the 30–100-MW (e) range. In addition, the Solar One test will provide electric utility personnel with first-hand experience, both in the operation and in the maintenance of the new technology. Utilities will monitor the information, experience, and performance data that develop from operation of the Solar One plant.

Next step: repowering

EPRI's Bigger believes information learned at Solar One, together with data from other ongoing experiments and central receiver pilot plants outside the United States, will pave the way for the next major step toward commercialization of solar-thermal conversion technology: implementation of a larger, precommercial project, probably a repowering plant. *Repowering* is a term applied to the concept of adding a solar-thermal conversion front end to an existing conventional fossil fuel power plant. Based on seven conceptual design studies recently completed (six were funded by DOE), the prospect exists that selected power plants



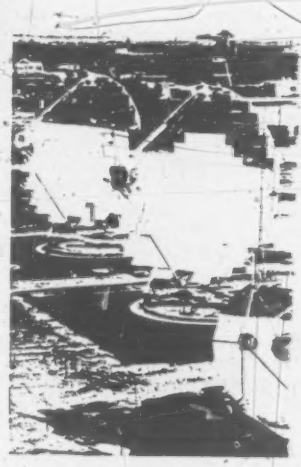
Flat plate collectors, like the rooftop unit providing energy for an air conditioning system at a Florida Power & Light Co. facility, are used to collect solar energy for water heating and the space heating and cooling of buildings.

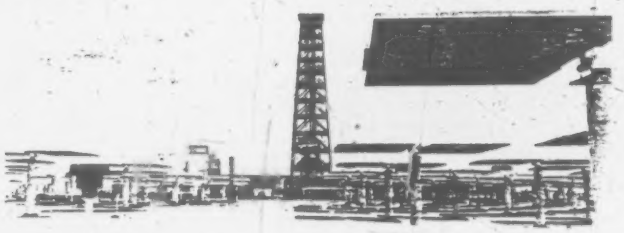


Line focus troughs reflect solar energy onto heat transfer fluid moving through a focal line. Such systems are demonstrating their capabilities in providing thermal energy for a wide range of industrial and agricultural processes.

Line focus bowls being tested under DOE sponsorship use a large number of mirror segments attached to a spherical structure to concentrate solar energy on the fluid moving along a line. This concept differs from the others in that the heat receiver moves rather than the reflectors. Heat collected in a number of bowls may be used for heating or cooling buildings, steam production, or small-scale electricity generation. (left)

Point focus dishes, like these DOE-funded test units, achieve high temperatures by using a number of mirrored reflectors attached to a single parabolic structure to focus intense solar heat on a receiver located at the focal point. Heat collected in this manner may be used to generate electricity, to provide energy for heating and cooling buildings, or to provide energy for many industrial and chemical processes. (right)





Central receivers, like this one near Barstow, California, achieve the high temperatures required for large-scale electricity generation by reflecting the energy received by hundreds of mirrored surfaces onto a single point, or receiver. The high temperatures achieved by central receiver units may also prove economic for many fuel and chemical production processes.

could be repowered and energy from the sun might replace as much as 20% of the expensive oil and gas now being burned. Future projects would demonstrate the concept of solar-thermal conversion in a conventional operating environment, and if the 20% savings in fossil fuels could be achieved at acceptable cost, such plants might be attractive.

Still, the cost of such systems remains a critical question. While the rising cost of fossil fuels is an obvious economic plus in the solar-thermal equation, it is also clear the cost of building the solar power plants is a major stumbling block. Estimates of the cost to modify and build solar repowering plants runs from $1500 to $4000/kW (in 1980 dollars), assuming a heliostat cost of about $250/m². EPRI analyses indicate that heliostats must be available for about half that cost if commercial solar-thermal plants are to compete with those now burning gas and oil for electricity generation. Even greater cost reductions would be needed to compete with coal-fired generating plants. Much of the development work supported by DOE's Solar-Thermal Program and under way in private industry is aimed at reducing costs by designing more efficient components and systems. Results of DOE's Second-Generation Heliostat Program were announced recently. This work covered a two-year test and development program with four potential heliostat suppliers. The results indicate the price of these new heliostats, if ordered in sufficient quantities, could approach the $110/m²–$150/m² range.

DOE has also examined a number of advanced central receiver concepts; the performance of each is considered to be better than the first-generation water-steam system now being installed at the Solar One pilot plant. These concepts include advanced water-steam systems, liquid-metal and molten-salt systems, and a combined-cycle concept. With DOE support, Martin Marietta has developed a 5-MW (th) molten-salt receiver, which was designed, built, and successfully tested at DOE's central receiver test facility (CRTF) at Sandia Laboratories in Albuquerque, New Mexico. A smaller-size liquid-metal (sodium) receiver panel was designed and built with private industry funds; it will undergo solar testing in the late-1981 through early-1982 time period.

Developing hybrid plants

The cost of developing solar-thermal energy is affected by an inherent handicap shared by all the emerging solar electric options: reliance on an intermittent source. How does a utility compensate for the lack of energy at night or on overcast days? To circumvent this problem, EPRI studies have concentrated on the Brayton-cycle gas-cooled solar-thermal system in a hybrid mode. Such hybrid power plants would use solar energy when the sun is shining, then burn oil or gas to generate electricity on cloudy days or at night. In contrast, the federal program is emphasizing thermal storage as part of the solar power plant. (The Solar One facility at Barstow was designed to have a thermal storage system capable of producing 7 MW (e) for four hours, using an oil and rock mixture inside a 60-ft-diameter tank storage vessel.)

Unlike the Rankine-cycle water-steam systems (such as is installed at Solar One), Brayton-cycle systems use air, helium, or other gas mixtures as the heat transfer fluid in the solar receiver (*EPRI Journal*, June 1979, pp. 18–21). Such systems, under development by EPRI and DOE, have been successfully tested at DOE's CRTF and at other solar-thermal test facilities at the Georgia Institute of Technology and the U.S. Army's White Sands Proving Ground.

Whereas Rankine-cycle systems operate in the temperature range of about 1000–1100°F (538–593°C), with pressures in the 1000–2000-psi (6.9–13.8-MPa) range, solar Brayton-cycle receivers have been successfully tested with air at temperatures in the 1500–2400°F (815–1315°C) range. These higher operating temperatures have the advantage of offering potentially higher efficiencies; they have the disadvantage of encountering material problems, usually at about 1500°F (816°C). To address these material problems, EPRI and DOE have sponsored studies aimed at developing and using high-temperature metallic alloy and ceramic components in Brayton-cycle receivers.

EPRI full-system experiment

The next step in the EPRI Solar Program is an experiment involving a complete Brayton-cycle solar-fossil hybrid system to generate electricity. Called the solar-fossil hybrid full-system experiment, the system is now being designed and will use the 1-MW (th) receiver previously tested at CRTF from October 1978 to March 1979, which was developed for EPRI by Boeing Engineering & Construction.

The commercial gas turbine to be used in the full-system experiment will be equipped with a parallel trim combustor, which allows fossil fuels to supplement the sun in a solar-fossil mode of operation and increases the system's operating flexibility and reliability. The parallel trim combustor concept was developed under a separate EPRI contract with Solar Turbines, Inc., which is bringing this experience to the full-system experiment as a subcontractor to Boeing.

In accordance with EPRI's goal of providing a link between research, development, and commercial implementation by the electric utilities, Public Service Co. of New Mexico is coordinating activities of the recently formed Utility Test and Operations Group, whose members represent about a dozen utilities, most of them located in the Southwest. This group will provide technical assistance to Boeing and will conduct the experiment during the solar operating phase. The experiment will give electric utility operating and engineering personnel firsthand exposure to a complete solar-fossil hybrid generating system.

Several of the southwestern utility companies participating in this experiment have also been taking part in DOE's repowering projects, and they can

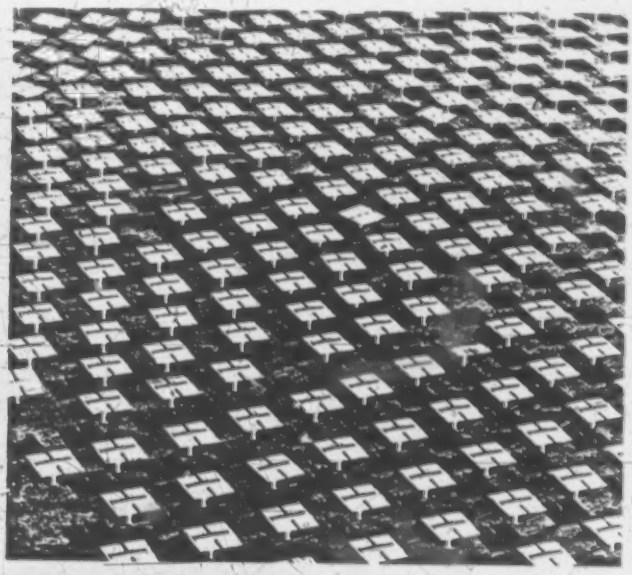
be expected to play a lead role in the development of solar-thermal conversion.

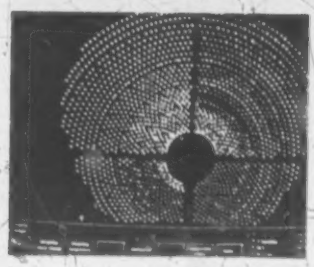
Information garnered from the full-system experiment and Solar One will be combined with data from other central receiver projects coming on-line throughout the world to advance solar-thermal central receiver technology and understanding.

Dishes, troughs, and bowls

In addition to the central receiver, or power tower, approach to solar-thermal energy conversion, considerable interest has also developed in various forms of dispersed, or distributed, solar-thermal systems. Such systems fall into two broad categories: point focus and line focus systems.

Point focus systems are similar to the power tower concept to the extent that the solar energy is focused on a central location. Rather than hundreds of heliostats focusing a solar beam at a distant receiver on top of a tower, however, a single mirrored tracking device in the shape of a parabolic dish captures the solar energy and focuses it on a receiver mounted a few feet above the dish. A special facility for testing dish systems and components is located at Edwards Air Force Base in California and is operated by Jet Propulsion Laboratory. Also, at Shenandoah, Georgia, DOE is currently building an array of parabolic dish concentrators to be used for electricity





Solar One, a 10-MW installation located near Barstow, California, is the nation's first solar-thermal central receiver electric generating station. A field of 1818 heliostats, controlled by computer, tracks the sun throughout the day and reflects its energy onto the receiver, where steam is produced. The steam is then sent either through heat exchangers for thermal storage and later use or to a conventional steam turbine that generates electricity. EPRI researchers believe information coming from the Solar One central receiver station will help advance this emerging technology and can lead to additional industry and utility commitments to continue its development.

SOLAR-THERMAL RESEARCH IN OTHER COUNTRIES

Interest in solar-thermal energy systems is not confined to the United States but is being actively pursued in a number of industrialized nations. Some of the major work currently under way includes the central receiver pilot projects described below.

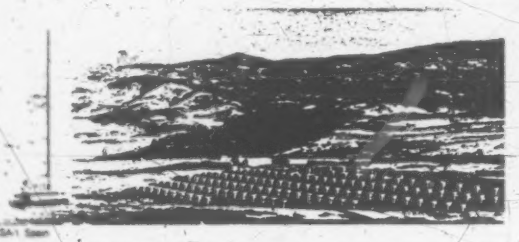
Almeria, Spain: The International Energy Agency has funded the construction of a 500-kW (e) small solar power system that uses liquid metal (sodium) as the heat transfer and thermal storage fluid. A cavity receiver located on top of a 140-ft (43-m) central receiver heats the sodium to 975°F (525°C). The 93 heliostats in the field provide 430 ft² (40 m²) of surface area and were supplied by the Martin Marietta Corp. The project is funded by several European countries and the United States; startup was in September 1981. This IEA installation also included a (nominal) 500-kW (e) line focus system for a direct comparison of performance with the adjacent central receiver.

Almeria, Spain: A 1.2-MW (e) central receiver system is under construction and scheduled for completion in late 1982. Called CESA-1, the unit uses a cavity receiver to produce 975°F (525°C) steam. A German and a French firm each supplied 150 heliostats with 430 ft² (40 m²) of surface area. The unit has a thermal storage capacity of 7 MWh (th) and uses Hytec as the storage fluid. Funding is being provided by the Spanish Joint Committee for Scientific and Technological Cooperation and the United States.

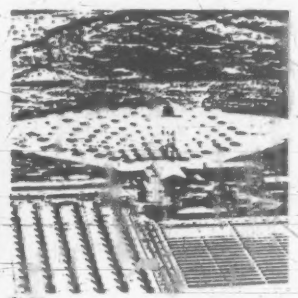
Adrano (Sicily), Italy: Eurelios, a 1-MW (e) central receiver solar power plant, began operation in May 1981. The cavity receiver sits on top of a 180-ft (55-m) tower and produces steam at 950°F (510°C). A 30-minute thermal storage subsystem is used to even out cloud transients, and Hytec is the storage fluid. The project was developed by a consortium from Italy, Germany, and France.

France: In the Themis project, a 2-MW (e) central receiver solar power plant will use molten salt as the transfer fluid, heated to 975°F (525°C) by solar energy reflected by 200 heliostats, each with a surface area of 560 ft² (52 m²) aimed at the cavity receiver. The storage system has 4 MWh (th) of capacity and uses Hytec as the storage medium. The project is scheduled to begin operation early next year.

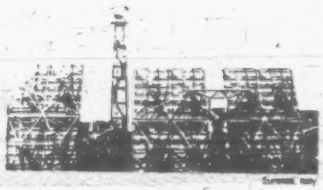
Nio Town (Nagawa Prefecture), Japan: A 1-MW (th) water-steam central receiver power plant went into operation earlier this year. The field consists of 807 heliostats, each providing 172 ft² (16 m²) of surface area; it reflects the sun's rays into a semicavity located on top of a 197-ft (60-m) tower and produces saturated steam at 480°F (250°C). Pressurized water is used as the thermal storage medium for 3 MWh (th) of heat storage. The project is completely funded by the Japanese Agency of Industrial Science and Technology and the Ministry of International Trade and Industry. □



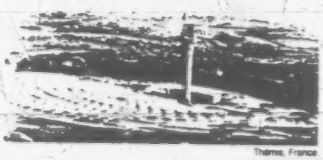
CESA-1, Spain



IEA, Spain



Sunwell, Italy



Thémis, France

Project Sunshine, Japan

generation, heating and cooling, and low-temperature steam production for a nearby knitwear plant.

Line focus, or trough, systems consist of a series of specially designed cylindrical or parabolic troughs lined with mirrors to collect and concentrate the sun's radiation. Under federal sponsorship, a number of the line focus systems have been installed at industrial and research sites. These systems usually operate in the lower temperature ranges, 200–600°F (93–316°C), adequate for providing industrial process heat, for operating small turbine generators, or for some specific commercial or industrial applications. Such uses might include irrigation pumping, for example, or steam injection for secondary oil recovery. Recent EPRI analyses indicate that line focus systems, because of temperature limitations, do not look favorable for large-scale electricity production.

Outlook

After an investment of many hundreds of millions of dollars in solar-thermal conversion technology since the early 1970s, where are we now and where do we go from here? Of all the solar-thermal technologies, only one is in commercial use: flat-plate collectors for water and space heating. The others are in various stages of development.

Of those solar-thermal technologies in development, the line focus systems have the most experience in field installations. This experience has been gathered in industrial and commercial process heat applications, where the temperature requirements are lower than those of utility power generation needs.

The point focus systems are the least developed of the solar-thermal technologies, but with further development they may have the capability for utility applications because they can achieve temperatures high enough for efficient electricity generation. Because the point focus systems are modular, they hold the potential for serving a wide range of electric requirements and may lend themselves to incremental installation.

Considerable resources have been expended on the development of central receiver systems, both in the United States and abroad. The technology holds significant promise for electric utilities as stand-alone plants that contain thermal storage systems; as solar repowering units tied to existing oil- and gas-fired units; and as new solar-fossil hybrid plants. It is also significant that a number of electric utilities have become directly involved in the studies and projects conducted by both DOE and EPRI.

With the level of federal solar program support sharply decreasing and future federal involvement increasingly cloudy, the corporate commitment of funds from suppliers and utilities needed for continued development will be determined in large measure by the analysis of results of solar-thermal conversion projects in the field today. These include not only the U.S. projects but also those experiments under way abroad, whose results will now become even more crucial. As these important data are collected, the next critical step in the development of solar-thermal power will be to ensure the broad and accurate dissemination of this information.

Further reading

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This article was written by Dan Van Ast, manager, Public Information. Technical information was provided by John Bigger, Advanced Power Systems Division.

BYRON J. WASHOM

Byron Washom is President of Advanco Corporation, a small research and development firm located in El Segundo, California. Recently, Advanco was selected to negotiate a $2.9 million cooperative agreement in the parabolic dish-Stirling program. Advanco and its co-participants will cost-share over $850,000. For the past two years, Advanco has served as the system integrator and test manager of the dish-Stirling program which has produced world record sunlight to electricity conversion efficiencies.

Mr. Washom holds a B.S. and M.B.A. from the University of Southern California and in 1976 was accepted and participated in the Massachusetts Institute of Technology's special graduate student program in the School of Engineering. Mr. Washom has authored and/or co-authored in the energy field three books, over 25 articles and seven Congressional testimonies. He is the former Manager of Technology and Policy in the Advanced Projects Department of Fairchild Stratos. Mr. Washom has served as vice-chairman of the Solar Thermal Division of the Solar Energy Industries Association since September 1980.

Mr. FUQUA. Thank you very much, Mr. Washom.

We will proceed with the other two witnesses and then we will have questions.

Mr. Seielstad.

STATEMENT OF HAROLD E. SEIELSTAD, ENERGY RESEARCH DEPARTMENT, PACIFIC GAS & ELECTRIC CO.

Mr. SEIELSTAD. Mr. Chairman and members of the subcommittee, I am very pleased to be here today to have an opportunity to share with you some of the results of 4 years of solar technology assessment by Pacific Gas & Electric Co.

First, I would like to make some comments on the historic situation of the utilities and then move on to the specifics on solar central receiver technology.

In the last 10 years, the Nation's electric utility industry has seen some incredible changes. Ten years ago the price of our fuel oil was $2.50 a barrel. Last year it was $40 a barrel.

The cost of conventional powerplant construction has changed in this decade from $750 a kilowatt installed to $3,400 a kilowatt installed.

Over this same decade, the cost of borrowed capital has risen from 8 percent to 16 percent, and happily, at least, we have one statistical figure, which is the annual growth and peak demand for our company, which has changed from 8 percent to 2½ percent.

Under these circumstances, we cannot proceed as we have historically to finance and build new capacity, to meet new demand, or to replace obsolete powerplants. Therefore, we do have to look in some new directions, and we do need new technologies to be perfected and made available to us.

We would like to see a focus at this point on utilization of domestic energy resources, principally, domestic uranium, domestic coal, and domestic sunshine.

Our focus at P.G. & E. on solar technology assessment has obviously been on the need to reduce our dependency on oil and gas, and we have examined the entire spectrum of renewable energy resources from this standpoint. We have examined the possibilities of our customers utilizing solar energy to reduce their need for purchased energy which, in turn, reduces our need to build new capacity.

We have looked at the entire range of technologies which are capable of generating electricity which include wind generation, small hydro, OTEC, solar power satellites, wave and tidal generators, parabolic dishes and troughs, solar ponds, and finally solar thermal central receivers.

It is my conclusion that the solar thermal central receiver technology is that which offers the greatest potential of economic and reliable power which can be perfected in this decade. They have several very salutary advantages. They do not have a combustion process; and, therefore, there is no air pollution, water pollution, or solid waste to be disposed of. They are an oil-conserving technology, and one 100-megawatt powerplant can conserve 500,000 barrels of oil per year in the peaking mode. It is a capital-intensive technology which does mean that it generates a great many jobs through-

out the economy and throughout the country. Finally, the quantitative potential of this technology is truly enormous. It is interesting to note that if one were to utilize 1 percent of California desert land, one could accommodate 26,500 megawatts of solar thermal central receiver capacity which just happens to be almost exactly equal to the total oil- and gas-fired electric generation capacity in the State of California at this time. Therefore, 1 percent of our desert or 250,000 acres could create that much new energy.

I am not suggesting it would be a desirable approach to develop it that heavily, but it is an interesting quantitative benchmark.

I would like to do a review now of three milestones which I think we can go through in this technological scenario. The first milestone is the past. It is the era which has been dominated by research and development, and which is now gradually coming to an end. The culminating event of this R. & D. period is now in the completion and operation of Solar I, the 10-megawatt pilot plant of Barstow, in which the Congress has very wisely invested $120 million to bring this technology to a demonstration point.

In addition, under the last decade of work, we have seen a great many other accomplishments. The 4 years of operation of the central receiver test facility at Albuquerque, N. Mex., has provided indispensible data, both on the development of receivers and the development of heliostats. We have seen first- and second-generation heliostats developed and perfected. We have seen four manufacturers develop these second-generation heliostats and have them available for the repowering program and for stand-alone plants. We have seen four different receiver technologies successfully test it using four different heat transfer elements: air, water, molten salt, and liquid sodium. We have completed numerous studies on such things as repowering to show the feasibility of utilizing solar central receiver technology to pick up part of the load of present oil- and gas-fired powerplants. We have seen studies on solar cogeneration, one of which our company participated in to examine the feasibility of a facility to both generate electricity and create process steam for enhanced oil recovery in a Kern Basin oilfield.

We now are gradually moving from this series of historic accomplishments into the present phase—the second milestone—which is that of demonstration. To those of us in utilities, the most important event is the imminent operation of Solar I which will begin to generate actual performance data, reliability, and operations, and maintenance data which will build a believable data base that we can act upon into the future. We will also see the refinement of the earlier repowering studies and a reduction of the financial risks by further analysis and further detailing.

We hope to see continued operation of the CRTF, perhaps as a combined research facility and an integrated molten salt receiver experiment. Finally, and perhaps most importantly, we hope to see the actual construction of some repowered plants using solar central receiver technology. From that increasing data base, we will have the confidence to move from this second milestone, the phase of demonstration, on into the future, the final commercialization of this technology.

STCR, if we have the support of the Congress in two vital areas, will achieve its one-quad potential by the end of the century. How-

ever, that is very heavily dependent on two very important actions. One is continuing Federal funding of these final phases of technology, and the sustenance and extension of the solar tax credit beyond 1985 until approximately 1995.

On moving from some comments on technology to economics, solar central receivers lend themselves rather well to this new financial situation of the Nation's utilities. With our cost-of-borrowed capital as high as it is and our rates of return as low as they are, we cannot use conventional financing. Therefore, the potentiality of third-party, venture-capital financing of solar central receivers is quite appealing to us.

These plants will probably be optimized around 100 megawatts in size. They can be built in 4 years, thereby allowing us to plan new capacity on a relatively shorter timeframe than we have, bring them on line, and be a purchaser of energy through PURPA-avoided cost stipulation.

Finally, I would like to comment on the effectiveness of the Solar Thermal Office at DOE. From a utility perspective, we have seen a program over the last several years that has been very realistic, and very centered on the needs of the user, the needs of the utility. We would strongly urge that direction to be continued, to bring the technology into the commercial phase, rather than a change in emphasis to generic R. & D.

In summation, I would like to see that we do find solar central receivers to be a promising renewable electric generation technology. It reduces our dependence on oil. It will create new jobs. It is safe. It is environmentally desirable. I think it is thoroughly worthy of the support of the Congress in this recommendation of STEA for a $59 million appropriation for fiscal year 1983.

Thank you.

[The prepared statement of Mr. Seielstad follows:]

PREPARED STATEMENT OF HAROLD E. SEIELSTAD

Mr. Chairman, Members of the Committee, I am pleased to have this opportunity to address you on my work in solar thermal central receiver (STCR) technology. For the past four years I have had the fascinating task at PGandE of conducting solar technology assessment. Very recently I have become chairman of the Solar Central Receiver Council, a new function within the Solar Energy Industries Association to provide utility and industry representation on STCR technology. Today I wish to address both the background and the specifics of STCR in particular.

The past decade has been a time of extraordinary change for the nation's electric utility industry.

- Ten years ago the price of fuel oil was $2.50 per barrel.
- Ten years ago conventional power plants cost around $750/kW installed and could be completed in eight years.
- Ten years ago the cost of borrowed capital was 8 percent.
- Ten years ago PGandE's annual growth in peak demand was 8 percent.

Now all these factors and many more have changed dramatically.

- The average 1981 cost of low sulphur fuel oil was approximately $40 per barrel.
- The cost of new coal power plants, our major available base load technology, is now about $3,400/kW to completion over a 12-year period.
- The cost of capital is now around 16 percent.
- PGandE's expected growth in peak demand for 1982 is about 2.5 percent.

Inflation has driven up all other costs of operating and maintaining utility systems and of building new facilities. Therefore, utilities are going through an agonizing reappraisal of their plans for new electric generation capacity, both to accommodate growth and replace or upgrade old generators. The drop in demand growth postpones the need for many new projects but does not diminish the need to replace or upgrade the oil and gas fired plants which have become very expensive to operate since the numerous OPEC related oil price increases beginning in 1973.

The lessons learned from our dependence on considerable imported petroleum should lead to a wise national energy policy for electric generation. This would focus on diversity within domestic resources. Nuclear plants consuming our own uranium, coal plants using our abundant coal and solar plants utilizing inexhaustable sunshine would protect our economy from unwelcome political and economic shocks. Heavy dependence on one particular resource and neglect of another is not a prudent policy.

Utilities need generation options among which to choose for their diverse requirements. When a developing technology meets certain criteria of availability, economy and reliability, it can then be utilized. It is desirable to us that STCR join the family of technologies which include clean coal, cogeneration and geothermal.

These new circumstances of rapid change have given rise to a new electric resource planning policy. There is a need for smaller modules of capacity, which can be built and added into a utility's rate base more quickly, involve less capital at low risk, or be amenable to financing by third party venture capitalists.

PG&E's solar technology assessment task has been mainly directed at how our company can reduce our dependence on non-renewable oil and gas. Our company has about 7,900 Mw of such capacity, some of which will need replacement in the years to come. We have examined the entire range of renewable energy technology including active and passive solar space and water heating, solar industrial process heat, solar cogeneration, biomass for new gas and electric generation, wind generation, solar power satellites, OTEC, small hydro, photovoltaic cells, wave and tidal generators, parabolic dishes and troughs, solar ponds and solar thermal central receivers. Many of these technologies are geographically specific and their potential will vary greatly from one utility to the next. And each utility has a different generation mix with which to integrate the renewable technologies. Thus each utility will have a somewhat different response to the opportunities of utilizing renewable energy resources.

It is my conclusion that STCR technology shows substantial promise of providing economic and reliable energy across the spectrum of requirements from peaking to intermediate to quasi-base load.

Solar thermal central receivers have other attractive advantages.

- They involve no combustion process and thus produce no air pollution, no water pollution and have no solid wastes for disposal. These three items have been a major area of economic uncertainty in development of other forms of thermal generation such as oil, coal and nuclear in this past decade of change.

- STCR is an oil conserving technology. Each 100 Mw peaking plant could displace about one-half million barrels of oil per year. Reduction of oil consumption benefits the economy and the security of the entire nation

- Since STCR is capital intensive it will provide numerous jobs in hundreds of large and small manufacturing plants across the entire country.

- The quantitative potential of STCR is as vast as the southwestern desert. The replacement of California's current 26,500 Mw of oil and gas fired capacity would require 250,000 acres of land which is only 1% of the California desert. And California's needs for new capacity would not likely consume even that 1% for many decades.

I would now like to present the three milestones of this technology.

The First Milestone - The Past - Research and Development

The accomplishments of the past eight years are about to be fulfilled in the first milestone - the essential completion of the research and development phase. The Congress has wisely invested $120 million in the climactic event of this phase--the completion of Solar One. The events that have built to this first milestone include:

- Four years of operation of the Central Receiver Test Facility (CRTF) at Albuquerque providing vital research support for both heliostats and receivers.

- Numerous studies defining STCR as a technology with very attractive flexibility between peak, intermediate and quasi-base load capability by virtue of the attractive economics of stored thermal energy.

- Completion of six repowering studies further advancing both the technology and economics. In each case an existing power plant currently fueled with natural gas or oil is adjacent to land suitable for a heliostat field and tower. The utility could operate the plant on sunny days with reduced oil or gas, and continue operation at night and on rainy days using oil or gas. Depending on the amount of thermal storage incorporated into the plants, one can also operate on stored solar energy well into the evening or during cloudy weather.

- Seven studies on solar cogeneration. In one of these PGandE cooperated with Exxon and Martin Marietta to study a solar central receiver which would provide electricity to our grid and steam to recover high viscosity oil from a field near Bakersfield, California.

- Construction of a molten salt storage test facility at CRTF.

- Completion by Sandia Laboratories of testing of second generation heliostats developed by four manufacturers for use in the repowering program and beyond in commerical stand-alone plants.

- Successful tests at CRTF of four different receiver designs using four different heat transfer fluids: air, water, salt and sodium.

- The completion and imminent operation of Solar One. This 10 MWe pilot plant employs 1818 first generation heliostats, a water steam receiver, and an oil rock storage system to provide a peaking plant capability.

The first milestone has been the period of highest risk and uncertainty. We now commence a transition period to:

The Second Milestone - The Present - Demonstration

As the first milestone passes into history, we are embarking upon accomplishing the second milestone - the fulfillment of the repowering program. This second milestone will be the time of transition from R&D to demonstration and precommercial applications. The events of the remainder of this decade should include the following:

- Operational performance data from Solar One which will build the all important data base on performance, reliability, and operations and maintenance for the series of larger scale repowering plants.
- Refinement of earlier repowering studies to quantify financial and technical risks. This risk definition and minimization phase is vital to implementing the involvement of venture capital.
- Finalization of plans to operate CRTF as a combined research facility and small power plant using a molten salt receiver and storage system.
- Operation by mid-1982 of a prototype 1 Mwt solar central receiver near Taft, California, for enhanced oil recovery using second generation heliostats and funded entirely by private industry.
- Construction of several repowered plants ranging from 30 to 100 MW utilizing both molten salt and sodium receiver technology and advanced second generation heliostats. It is vital that at least two different receiver manufacturers and two different heliostat manufacturers participate to maintain a competitive environment of choice by utilities and industrial users.

Finally and most importantly, the accumulated data base from these many sources will enable the manufacturers to speak to utilities in realistic terms of performance, warranties, fixed cost and financing arrangements. Adequate funding in the Federal FY83 budget will be required for this transition from pilot plant to commercialization to take place, so that actual solar central receiver plants can be built in this decade to repower oil and gas fired plants directly, and repower grids fed by oil and gas fired plants.

The path of fulfillment to reach the commercialization threshold, requires two major actions by the Congress. One is continued Federal funding of the final stages of transition from RD&D to commercialization. The other is the continuance and extension of the solar tax credits beyond current expiration in 1985, to the year 1995. This is the preparatory period to achievement of the final phase:

The Third Milestone - The Future - Commercialization

As the second milestone is realized, we will look to the achievement of the third milestone - true commercialization of stand-alone solar

thermal central receiver power plants in substantial numbers in the final decade of this century. This will be a time of major implementation without the formerly vital assistance of the solar energy tax credit or Federal funding of RD&D. It will move the technology toward its one quad potential by the end of the century and contribute its part to the goal of reducing our national energy dependence upon oil and gas. In this period beyond 1995, we will have come through the first period of high risk, high potential research and development, through the period of demonstration and risk reduction, to the final phase of competing on equal unsubsidized terms with every other energy technology.

The Federal government can then take pride in a job well done, and in having accelerated a valuable new resource into being in 20 years that would have taken at least 30 years without substantial funding from the Congress.

It is now 1982 and the second milestone is undertaken. It is in the hands of this Congress as to whether this will move forward to fulfillment or come to a halt in frustration.

Economics

Solar thermal central receiver technology will lend itself ideally to the new economic operating environment of the electric utilities. Studies to date indicate these power plants will be economically optimal around 100 MWe capacity. The initial capital cost will be around $3,000/kW installed, with a potential for reduction as mass manufacturing of heliostats develops. This will provide a levelized busbar cost of energy that is competitive with oil. A modular 100 MW plant can be built in four years and become an earning part of the rate base at a much earlier time than conventional power plants. As an alternative to utility ownership, these plants lend themselves to financing by third party venture capitalists, thus relieving utilities of investing any of their own capital in this form of new generation capacity. For example, in 1981 our Company had an earned rate of return of about 9 percent and a cost of borrowed capital of about 16 percent. Clearly any investment in new generation is financially damaging to our stockholders, bondholders and customers. As a result, many utilities are seeking financing by third party venture capitalists. This path is all the more persuasive since utilities currently do not benefit from solar tax credits. Utilities are required to purchase electricity from the plant owners at avoided cost under PURPA or at a negotiated variant thereof. And there are other variants of this arrangement where a utility can buy steam or shaft horsepower on a negotiated basis from the plant owners, putting a relatively small amount of capital into the lowest risk portion of the plant, the steam turbine-generator which uses long proven technology.

The venture capitalist and/or manufacturer of solar central receivers will find such arrangements advantageous only if the current solar energy tax credits are extended thru the transition period to the commercialization era. A company would be encouraged to take the risk of major investment in a new technology if the government shares that risk

indirectly via the solar energy tax credits. Because plans developing right now could not be implemented until 1986-1987, it would be too late to qualify for the present credit which expires in 1985. So an urgent need exists to extend the tax credit until 1995, because the first generation of solar central receivers should enjoy this benefit during the introductory period of a new technology. After 1995 a sufficient number of operating plants will be in existence to have a substantial data base on the current unknowns of operations and maintenance and reliability. And mass manufacturing of heliostats will be developed to reduce or stabilize costs.

If the Federal Government were to cease funding of the repowering program now, cease to support some remaining R&D tasks, cease to operate the CRTF, or cease to fund the operation of the 10 MW pilot plant, the evolution of this technology would be irreparably disrupted. At this time the uncertainties and risks are too high for the free enterprise community to proceed with commercialization. But we are on the path of building sufficient confidence in the reliability of hardware, in the estimates of the operation and maintenance costs, and the economic risks of plant development to accomplish the third milestone without Federal funding.

The DOE Solar Thermal Office has brought this technology from the research state to the demonstration state in only five years, a most commendable achievement. The program of focusing on user requirements and emphasizing an approach to reduce the risks to commercialization is appropriate and welcome. Continuation on this successful historic path continues to offer the greatest likelihood of achieving true commercialization in this decade. On the other hand, a change to a generic R&D emphasis would not serve the user interest, and would not expedite availability of this promising oil conserving technology to either utilities or industry.

In summation, solar central receivers are a uniquely promising renewable electric generation technology. The utilities in high insolation areas will be the dominant customers for STCR. We welcome a new perfected energy generation technology in this time of rapid change. STCR will reduce our dependence on oil and create new jobs which benefit the entire nation. If we do not proceed to completion in this program, it is all too likely that foreign entrepreneurs will fill the void. We would prefer to use American technology. Solar central receivers are safe, environmentally desirable, and draw on a no-cost renewable resource--the sun.

I urge the Congress to support the $59.5 million Solar Thermal Energy Association budget recommendations for FY 1983 so history will show their promise can be fulfilled.

Thank you,

Harold E. Seielstad

RESUME HAROLD E. SEIELSTAD

Over the past 22 years Mr. Seielstad has acquired a unique and diverse background in environment and energy, marketing, management and research.

PROFESSIONAL POSITIONS:

SENIOR SOLAR ENGINEER, Pacific Gas and Electric Company. Originated a program of research and planning for utilization of solar thermal central receivers in stand alone and cogeneration applications. Encouraged experimentation with vertical axis wind generators and photovoltaics. Developed the only utility sponsored program of passive solar research. Developed Suntherm program to expedite builder adoption of passive solar design. Created solar program to increase utility access to various forms of solar energy including solar total energy systems on customer premises. Mr. Seielstad is in charge of the solar technology assessment program to maintain the most current technological input. (1978-present)

CONSULTANT for solar energy utilization studies, Natural Resources Defense Council, Palo Alto, California; studies on environmental assessment of alternative sources of electrical energy, Electric Power Research Institute, Palo Alto; Director of Research, NO on 15 Committee, San Francisco, California. Mr. Seielstad was responsible for developing technical arguments on reactor safety, waste disposal, energy conservation, alternative sources, environmental impact and economics of nuclear power. He wrote literature, speeches, and participated in numerous presentations, debates, and interviews with press, radio, and television regarding Proposition 15. (1976-1977)

EXECUTIVE DIRECTOR, Zero Population Growth, Palo Alto, California. (1971-1973)

PRESIDENT, Environmental Instruments Company, Menlo Park, California. (1970-1971)

MANAGER OF MARKETING, Physics International Company, San Leandro, California. (1967-1969)

MARKETING MANAGER AND SENIOR SCIENTIST, Teledyne Isotopes, Inc., Westwood, New Jersey and Palo Alto, California. (1964-1966)

PROJECT ENGINEER, Northrop Corporation, Hawthorne and Newbury Park, California. (1959-1964)

RELATED ACHIEVEMENTS: Designed and constructed four passive solar test cells to determine performance of various structural and manufactured space heating elements such as trombe wall, thermic diode, water wall, and phase change salts. Conducted tests on advanced active collectors including evacuated tube and glazed plastic collectors.

Developed the solar electric subdivision concept of using passive solar space heating and active solar water heating with neighborhood utility owned storage. Backup energy is derived off peak from a utility owned solar assisted heat pump.

Mr. Seielstad was architect, engineer and contractor for his own active solar home, passive solar greenhouse and guesthouse, swimming pool and hot tub to demonstrate cost effective and maximal use of alternative energy.

EDUCATION: M.S., University of California, Los Angeles. Nuclear Engineering. B.S., University of Texas, Nuclear Physics. A.A., Del Mar College, Corpus Christi, Texas.

AFFILIATIONS: Founder and Chairman - Solar Central Receiver Council of SEIA. Chairman - American Gas Association, Solar Technology Committee. Member - National Science Foundation Alternate Energy Advisory Board, Solar Repowering Utility Advisory Committee, Solar One Advisory Committee, Solar Two Utility Advisory Board, Solar Repowering Council, Southwest Solar Repowering Utility Advisory Council. Life Member California Academy of Science. Consultant on Energy Ethics to the President of the Lutheran Church in America. Member International Solar Energy Society.

Mr. FUQUA. Thank you very much.
Mr. Berman.

STATEMENT OF ELLIOT BERMAN, ARCO SOLAR, INC., ACCOMPANIED BY GEORGE TENET, DIRECTOR, PHOTOVOLTAIC AND INTERNATIONAL PROGRAMS, SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. BERMAN. Chairman Fuqua, members and guests, good morning. My name is Elliot Berman, and I am chairman of the Photovoltaic Division of the Solar Energy Industries Association. On behalf of the division and the companies it represents, I want to thank you for this opportunity to have our views considered by this committee.

Before I begin my testimony, I would like to introduce George Tenet who is sitting with us. George is with SEIA and he is the one who does all the work.

Mr. FUQUA. We are very happy to have you, Mr. Tenet.

Mr. TENET. Thank you.

Mr. BERMAN. First, I wish to tell you that the photovoltaic division of SEIA is enjoying continued growth as is our industry.

Strategies Unlimited reports that the worldwide sales of photovoltaic products have grown from a 1.5-megawatt peak in 1979 to an estimated 8.9-megawatt peak in 1982.

U.S. Government support for the industry has played an important role in our successful development. At this point, however, we see a need for a change in the type of Government support given to our industry. There is a need for a transition from an almost Government-directed role to a more traditional, supportive one.

Today, I will present the views of our industry on how the transition might best be accomplished. We seek supportive and stable Federal action in the areas of basic research, transitional activities, and market stimulation.

Although Mr. Tenet has worked diligently to gather information from our industry, much of what you hear today, and certainly what you will hear in the question-and-answer period, is colored by my own personal experiences and my own biases. Therefore, I would like to provide a brief summary of my career.

I have spent over 25 years in U.S. industry in the field of photochemistry, photophysics, and solar energy utilization. In 1969, I founded Solar Power Corp., the first company devoted exclusively to the manufacture and marketing of terrestrial solar cells. I also served as president of Sun Systems, Inc., a small business which manufactures and markets flat-plate solar water and solar air heating systems, as well as an insulation measuring device. I am presently chief scientist for ARCO Solar, Inc., a subsidiary of Atlantic Richfield Co.

Now, to get back to the position of the photovoltaic industry. First, we believe that the Federal Government, as I said, has a continuing vital role to play in accelerating the economic use of photovoltaic energy. We believe it is appropriate for the Government to play this role on the basis of the importance this industry will have in our Nation's future.

Successful development of economic electricity from our Sur. requires only two things: economic devices and an industry to produce and market these devices.

First, in terms of current industry needs, there is one activity of the Federal Government that is agreed on as being central to our current and future growth. In our economic system, it is the one governmental action that supports, stimulates, and encourages our industry without distorting or possibly stunting its growth. Here I am referring to the business energy tax credit.

The maintenance and extension of the current 15-percent business energy tax credit is crucial to our continued growth. Its expansion to 30 percent and extension for an additional 5 years would be the single most economic and effective action that the U.S. Government could take.

Now, I would like to mention some transitional things that we feel are important to see continued. Over the past several years, there have been a large number of DOE-sponsored photovoltaic demonstration installations. We believe these deserve to be adequately maintained if they are to be an asset to the industry's marketing efforts rather than a liability.

Further, information about the performance, maintenance, and other key data from these installations can play a very beneficial role for the industry.

The area of standards and tests has been heavily subsidized, if not totally sponsored by DOE. This represents a particular problem for the small business members of our association. Unless funding is provided for an adequate transition, the cost to test products may be prohibitive for small business.

The photovoltaic industry and all solar industries need the development of a global sunlight data base. The data already exists. It is collected by our weather satellites, but it is not now available in useful form. Therefore, the Government could assist the industry greatly by inventoring our solar fuel source on a worldwide basis.

The division recognizes the need for a large-scale utility experiment expanding the Sacramento municipal utility district program beyond its initial one megawatt.

Now, I would like to turn to the area which is the largest budgetary section of our recommendations, which has to do with the future of the industry: the area of research.

To introduce this section of my testimony, I would like to quote from Gulliver's Travels by Jonathan Swift, published in 1726. Gulliver is visiting the Grand Academy of Lagado, a Government-funded research institute. I quote:

> The first man I saw was of a meagre aspect, with sooty hands and face, his hair and beard long, ragged and singed in several places. His clothes, shirt and skin were all of the same color. He had been 8 years upon a project for extracting sunbeams out of cucumbers, which were to be put into vials hermetically sealed, and let out to warm the air in raw inclement summers. He told me, he had no doubt in 8 years more, that he should be able to supply the governor's gardens with sunshine at a reasonable rate; but he complained that his stock was low, and intreated me to give him something as an encouragement to ingenuity, especially since this had been a very dear season for cucumbers. I made him a small present, for my lord had furnished me with money on purpose, because he knew their practice of begging from all who go to see them.

I and many of my research colleagues are well described by Swift. We have been engaged in solar energy research for a long time; we are optimists; we are always halfway there; and we always need more money.

There is no question that substantial reduction in the cost of solar cells is required before these systems can have a major positive effect upon our Nation's needs. These cost reductions require five things: the discovery of potentially low-cost material, a fundamental understanding of potentially low-cost material, and the development of manufacturing, packaging, and deployment technology for these materials.

Discovery is not the sole province of individuals, large or small business, academia, or Government. All contribute.

A fundamental understanding of materials and their workings require high-caliber technical people and equipment in a stable environment. Industry, Government, and academia will contribute together in this area if the national objective is clear.

In our society, the development of manufacturing, packaging and deployment technology is the province of industry.

Finally, I will turn to our recommendations. We believe that U.S. industry efforts would be substantially accelerated if a Government laboratory center of excellence existed that was conducting research directed to the discovery of potentially low-cost materials and a fundamental understanding of solar devices. This institute would be given sufficient funding on a continuing basis to support a high-quality group of scientists with high-quality equipment.

It is not possible to carry out these long-range activities in an unstable environment with constantly changing goals and directives. A major portion of the institute's activity would be conducted in-house with the ability to contract some work to universities, small business, and other Government laboratories. The institute would have the ability to perform specialized measurements and characterization work for industry. In short, the institute could function as a focal point to care for current needs, such as those already discussed, as well as future requirements.

The institute must have the ability, we believe, to accept industry scientists to work in its laboratories for 3-month to 1-year terms, during which time the knowledge developed would be directly transferred to industry. This interaction would provide not only for information transfer from the institute to the industry, but it would give direct feedback to the institute of industry's needs and goals.

Industry representatives would return to their companies having learned the state of the art and they would begin their own efforts to build on this knowledge and produce commercially important, patentable innovations of their own.

These arrangements which sound idyllic, I suppose, already exist in Japan and France.

We believe that the Federal support should be focused on research activities on thin film and other innovative devices that have the potential of bringing the price of photovoltaic-generated electricity to that at least competitive with other options.

We recommend that this support be implemented through a single Government organization with a single focus, that is, solar

energy. We further recommend that industry and academia have a direct hand in its program selection process.

I believe that the Solar Energy Research Institute is a viable foundation on which to build a Government laboratory center of excellence.

To summarize, one, the business energy investment tax credit must be maintained, extended, and expanded.

Two, we strongly recommend that you authorize the establishment of a National Laboratory Center of Excellence. We estimate funding requirements to take care of the current industry needs at the level of about $6 million and research funding requirements of the order of $30 million a year over the next several years.

We also recommend that you proceed with the authorization for stage two of SMUD and attendant balance of systems—estimated funding requirements of about $10 million.

Finally, returning to Gulliver's Travels, the Grand Academy of Lagado consisted of a group of well-intentioned Government employees doing research without regard for the real world or the cost of cucumbers. We believe our recommendations will create the necessary cooperation between the public and private sectors leading to the rapid successful development of photovoltaic systems essential to the Nation's future. Thank you.

[The prepared statement of Mr. Berman follows:]

PREPARED STATEMENT OF ELLIOT BERMAN

Chairman Fuqua, members, and guests, good morning. My name is Elliot Berman. I am Chairman of the Photovoltaic Division of the Solar Energy Industries Association (SEIA). On behalf of the Division and the companies it represents, I want to thank you for this opportunity to have our views considered by this committee.

First, I wish to tell you that the Photovoltaic Division of SEIA is enjoying continued growth. We now represent 34 members. This corresponds to a parallel growth in the industry itself. Strategies Unlimited of Mountain View, Calif., a respected independent market consulting firm, reports that worldwide sales of photovoltaic product have grown from 1.5 MWp in 1979 to 3.3 MWp in 1980, and 5.2 MWp in 1981 to an estimated 8.9 MWp in 1982. Furthermore, U.S. photovoltaic products are still recognized as representing the highest quality in the world market.

Members of the Association also recognize that you in Congress, as well as the Executive branch, face difficult decisions in these economically troubled times.

The U.S. photovoltaic industry is healthy, growing and vital. But we, too, find these to be difficult times for the development, manufacture, and sale of a new energy product as we face growing competition heavily subsidized, if not sponsored, by foreign governments. (Although total sales are growing, market share held by U.S. manufacturers took its first significant drop in 1981.)

U.S. government support for the industry has played an important role in our successful develoment. At this point, however, we see the need for a change in the type of government support given to our industry. There is a need for a transition from an almost government-directed role to a more traditional supportive one. We

would urge that this transition be conducted in a rapid but orderly fashion, in order to protect the interests of truly small businesses in the industry lacking the means to carry out certain key functions which have been provided by past government programs.

Today, I will present the views of our division on how that transition might best be accomplished. We seek supportive and stable Federal action in the following areas: Basic research, transitional activities, and market stimulation.

We have examined Administration proposals, as well as several other proposals and counterbudgets. But in recognition of this transition, we feel it is most appropriate to focus this testimony on industry interests, rather than presenting industry comments on various Federal proposals.

This is said with all due respect for the efforts which have gone into these budgets and proposals, and with no small appreciation for the interest they represent in the success of our industry. The success of our industry, however, depends primarily on us — with your support and help, of course.

Testifying from this perspective (that is, stating what we think should be done, rather than commenting on government proposals) is new for our Association. Therefore, I feel I should tell you what we have done to gather the information upon which this testimony is based. I, of course, cannot claim that the views I am about to present represent exactly the individual views of our industry. Efforts to elicit opinions of our industry include questionnaires sent by the SEIA staff in February. This mailing included in early form the budget we are proposing. A more detailed questionnaire on research priorities which I sent to the industry on March 3 for

their response is appended. Telephone conversations between the industry (both members and nonmenbers of SEIA's Photovoltaic Division, including small businesses) and myself and Mr. Tenet of the SEIA staff regarding this testimony during the past month have been extensive.

Even with all the information we gathered, much of what you hear today, and certainly what you will hear in the question-and-answer period, is colored by my own personal experiences and biases, since I was elected chairman and given this opportunity and responsibility to report on the industry. Therefore, if you will bear with me, I will provide a brief summary of my career, which is given in more detail in the biography at the end of my testimony. I have spent over 25 years in U.S. industry in the fields of photochemistry, photophysics and solar energy utilization. In 1969 I founded Solar Power Corporation, the first company devoted exclusively to the manufacture and marketing of terrestrial solar cells. I also served as president of Sun Systems, Inc., a small business which manufactures and markets flat-plate solar water and solar air heating systems, as well as an insolation measuring device. I am presently Chief Scientist for ARCO Solar, Inc., a subsidiary of Atlantic Richfield Company.

Let me return to the position of the Photovoltaic Division of SEIA. First, let me reiterate that we believe the Federal government has a continuing vital role to play in accelerating the economic use of photovoltaic energy. We believe it is appropriate for the Federal government to play this role, on the basis of the importance this industry will have in our nation's future balance of trade. The industry has great potential impact on national security needs, and can be a factor in the event of disruptions in national energy supply. Thus we believe that successful rapid development of the U.S. photovoltaic industry is important to the

nation's future.

Successful development of economic electricity from our sun requires two things: economic solar devices and an industry to produce and market those devices.

CURRENT INDUSTRY NEEDS

Of all the activities of the Federal government which might contribute to the development of the U.S. photovoltaic industry, there is one that is agreed upon as being central to our current and future growth. In our economic system, it is the one governmental action that supports, stimulates and encourages our industry without distorting or possibly stunting its growth. Here, I am referring to the business energy tax credit.

The maintenance and extension of the current 15-percent business energy tax credit is crucial to our continued growth. Its expansion to 30 percent and extension for an additional five years would be the single most economic and effective action that the U.S. government could take. According to our calculations, this credit would cost the Treasury no more than $7 million for each 15 percent of the credit's value during this year. This could reach $35 million during the fifth year.

I understand that this issue is beyond the jurisdiction of this committee; but as the committee that has been most involved with and concerned about this industry, we would hope that you would do everything possible to promote this action.

We would also seek your assistance in another important area that may be beyond the purview of your committee. Since a major portion of our near-term business is and will be conducted overseas, we will continue to require assistance in

overcoming foreign trade barriers. In addition to the standard support that is generally provided by the U.S. Department of Commerce on behalf of all U.S. industry, we feel that special attention should be directed to what appears to be a growing protectionist tendency of foreign countries toward U.S. manufacturers of photovoltaic technology.

Now, let us discuss areas in which this committee has direct jurisdiction:

Areas of near-term importance in addition to the tax credit and foreign trade assistance:

Maintenance and monitoring of existing DOE-sponsored photovoltaic demonstration installations: A large number of photovoltaic installations deployed by DOE deserve to be adequately maintained if they are to be an asset to the industry's marketing efforts rather than a liability. Furthermore, information about the performance, maintenance and other key data from these installations can play a very beneficial role for the industry. If this were not done, these installations might turn into an embarrassment to the government as well as U.S. industry, and currently it appears no adequate plans have been made to ensure this is performed.

Standards and Tests: This area, which has been heavily subsidized, if not totally sponsored by, DOE, represents a particular problem for the small business membership of our association. Unless funding is provided for an adequate transition, the cost to test products may be prohibitive. In the area of standards, the leadership position of the United States can be threatened without some continued transition funding over the next several years while the industry grows and organizes itself to take up this very important effort.

Development of a global insolation data base: Employing data from our weather satellites which is currently collected but not available in a useful form, the U.S. government could assist the industry greatly by inventorying our fuel source on a worldwide basis. There is no adequate information about insolation for many parts of this country as well as great portions of the rest of the world. Assembling and processing this data from that already collected by our satellites would provide a major boost to the development of our industry here as well as abroad.

Development of a large-scale utility project and the attendant balance of systems efforts: This can have an important beneficial effect for the U.S. photovoltaic industry. The SEIA Photovoltaic Division recognizes the need for a large-scale utility experiment expanding the Sacramento Municipal Utility District (SMUD) project beyond its initial one megawatt. Continuing on with the plan of development in this area will provide a much-needed experience in development, operation and maintenance of a major photovoltaic component for a willing utility partner located on the Pacific rim. The SMUD installation will offer a clear example of this nation's continuing commitment to the devlopment of high technology renewable resources.

Now I would like to consider that area which represents the largest budgetary segment of our proposal: that having to do with the future of the industry, the area of research. It is this area in which I am personally most at home.

To introduce this section of my testimony, I would like to quote from Gulliver's Travels by Jonathan Swift, published in 1792. Gulliver is visiting the Grand Academy of Lagado, a government-funded research institute:

"The first Man I saw was of a meagre Aspect, with sooty Hands and Face, his Hair and Beard long, ragged and singed in several Places. His Clothes, Shirt and Skin were all of the same Colour. He had been Eight Years upon a project for extracting Sun-Beams out of Cucumbers, which were to be put into Vials hermetically sealed, and let out to warm the Air in raw inclement Summers. He told me, he did not doubt in Eight Years more, that he should be able to supply the Governor's Gardens with Sunshine at a reasonable Rate; but he complained that his Stock was low, and intreated me to give him something as an Encouragement to Ingenuity, especially since this had been a very dear Season for Cucumbers. I made him a small Present, for my Lord had furnished me with Money on purpose, because he knew their Practice of begging from all who go to see them."

I and many of my research colleagues are well described by Swift. We have been engaged in solar energy research for a long time; we are optimists; we are always halfway there; and we always need more money.

Whatever the case, research on fundamental questions is important to the future development of the U.S. photovoltaic industry. So if you will forgive my "meagre aspect," I would like to present for your consideration our thoughts on not only what should be pursued by government-sponsored research, but just as importantly, how that pursuit can be structured to have the most beneficial impact on the industry.

First, I think it is important to note for the record that we believe our current technology is sound, and provides excellent product with good value for our current customers and their applications, which are primarily for remote sites where our products replace diesel generators.

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With that said, however, there is no question that substantial reduction in the cost of solar cell systems is required before these systems can have a major positive effect on our nation's needs. These reductions require the discovery of potentially low-cost materials, a fundamental understanding of potentially low-cost materials, and the development of manufacturing, packaging and deployment technology for these materials.

Discovery (invention) is not the sole province of individuals, large or small business, academia, or government. All contribute. I believe that past government programs in solar energy have suffered by overemphasizing the role of government program managers in the discovery process.

A fundamental understanding of materials and their workings requires high caliber technical people and equipment in a stable environment. Industry, government and academia will contribute together in this area if the national objective is clear.

In our society, the development of manufacturing, packaging and deployment technology is the province of industry.

We believe that U.S. industry efforts would be substantially accelerated if a government Laboratory Center of Excellence existed that was conducting research directed to the discovery of potentially low-cost materials and a fundamental understanding of solar devices. This Institute would be given sufficient funding on a continuing basis to support a high-quality group of scientists with high-quality equipment. It is not possible to properly carry out these long-range activities in an unstable environment with constantly changing goals and directives. A major portion of its activity would be conducted in-house, with the ability to contract

some work to universities, small businessess, and other government labortories. (We do not believe that the government should fund non-small business to conduct research of commercial importance.)

The Institute would have the ability to perform specialized measurements and characterization work for industry. In short, the Institute could function as a focal point to care for current needs such as those already discussed, as well as future requirements.

The Institute must have the ability to accept industry scientists to work in its laboratories for three-month to one-year terms, during which time the knowledge developed would be directly transferred to industry. This interaction would provide not only for information transfer from the Institute to industry, but give direct feedback to the Institute (Government) of industry's needs and goals. This arrangement has the advantages of research conducted in a university setting in terms of independence, stability, and excellence, but it offers a much more timely and practical infusion of knowledge to industry, through its representatives participating in their work.

Those representatives can then return to their companies, having learned the state of the art, and begin their own efforts to build on this knowledge and produce commercially important patentable innovations of their own. These "idyllic" arrangements already exist in Japan and France.

We believe that Federal support should be focused on research activities on thin film and other innovative devices that have the potential of bringing the price of photovoltaic-generated electricity to that at least competitive with other options.

We recommend that this support be implemented through a single government organization with a single focus, i.e., solar energy. We further recommend that industry and academia have a direct hand in its program selection process. Finally, it is very desirable for the type of Institution we have recommended that its stability and independence, in short, its research integrity, be guaranteed by providing for a governance structure composed of a board representing industry, academia and government as well as energy users, which insulates it from the whims and fancies of any transitory political situation.

I believe that the Solar Energy Research Institute is a viable foundation on which to build a Government Laboratory Center of Excellence.

To Summarize: The PV division of SEIA has the following requests and recommendations:

1) The business energy investment tax credit must be maintained, extended and expanded. This will provide the most effective and efficient stimulus to our industries' growth. This help plus attention and aid with foreign trade barriers will maintain the leadership of U.S. companies in the face of strong foreign competition in the near term. We request your help in these areas.

2) We strongly recommend that you authorize the establishment of a National Laboratory Center of Excellence, insulated from immediate political winds and whims; open to the direct participation of industry representatives and the focal point for current needs (such as the collection of global insolation data, transitional funding of standards and testing work as discussed above) and committed to research activities on thin film and other innovative

devices. We estimate funding requirements for current needs at six (6) million dollars and research funding requirements of the order of thirty (30) million dollars a year over the next several years.

3) We also recommend you proceed with the authorization for stage 2 of SMUD and attendant balance of systems (estimated funding requirements ten (10) million dollars.)

Finally, returning to Gulliver's Travels. The Grand Academy of Lagado consisted of a group of well-intentioned government employees doing research without regard to the real world or the cost of cucumbers. We believe our recommendations will create the necessary cooperation between the public and private sectors leading to the rapid, successful development of photovoltaic systems essential to the nation's future.

ELLIOT BERMAN

EXPERIENCE

April 1979 - Present: ARCO Solar, Inc.; Chief Scientist

1977 - 1979: Sun Systems, Inc., Boston, Massachusetts; President
Sun Systems, Inc., is a small business which manufacturers and markets flat-plate solar water and solar air heating systems and an insolation measuring device. Consultant to ARCO Solar, Inc., on photovoltaic research, systems development and marketing. Research Professor of Applied Science, Boston University.

1975 - 1977: Boston University; Director, Center for Energy Studies
Responsible for organizing and directing University activities in energy research, development, demonstration and education. Research Professor of Applied Science. Chairman, Program Committee, "Energy Workshops."

Director, New England Consortium for Environmental Protection. Consultant, Solar Power Corporation (now wholly owned subsidiary of Exxon Enterprises Inc.)

1969 - 1975: Solar Power Corporation, Braintree, Massachusetts; Founder, Chairman of the Board and President
Solar Power Corporation was the first company created exclusively to manufacture and market terrestrial solar cells.

1970 - 1973: Exxon Enterprises Inc., affiliate Exxon Corporation, New York, New York. Consultant: Special Assignment to Exxon Research and Engineering Company, Linden, New Jersey. Laboratory Director, Corporate Research Energy Conversion Unit.

1959 - 1969: Itek Corporation, Lexington, Massachusetts; Director, Corporate Research Laboratories

1955 - 1959: National Cash Register Company, Dayton, Ohio; Head, Organic Section, Fundamental Research Department

EDUCATION AND ASSOCIATIONS

Sc. B. in Chemistry, Brown University, 1951
Ph. D. in Chemistry, Boston University, 1956
American Chemical Society; Chemical Society (London); American Association for Advancement of Science; Society of Photographic Scientists and Engineers; Sigma XI; International Solar Energy Society; Institute for Electrical and Electronic Engineers; Fellow, American Institute of Chemists

PUBLICATIONS

Various publications regarding photochemistry and solar energy.

PATENTS

Twenty-seven (27) issued U.S. patents on reversible photochemical systems and unconventional photographic systems. Eighteen (18) U.S. patent applications pending on photochemical systems and solar energy devices.

Mr. FUQUA. Thank you very much, Mr. Berman.

You enclosed with your statement a questionnaire which you mailed out to the members of the Solar Energy Industry Association.

Mr. BERMAN. Yes.

Mr. FUQUA. Have you gotten the results of that back yet, and have they been compiled?

Mr. BERMAN. Well, actually, we have sent out two questionnaires. The second one is the one that you have.

Mr. FUQUA. It is dated March 3.

Mr. BERMAN. Yes; we have received answers at the present time from 20 members. By the way, I should point out that we sent out the questionnaire not only to members of the association, we sent it out to all people in the photovoltaic industry. We have had answers——

Mr. FUQUA. How many people are members of the association?

Mr. BERMAN. There are 35 members of the photovoltaic division. It is hard to guess the total number of members of our industry. There are probably on the order of 60 companies that would count themselves as being in our industry.

Mr. FUQUA. Could you provide us with the results?

Mr Berman. Yes; they are just now coming in. We would be happy to.

Mr. FUQUA. When it is completed.

Mr. BERMAN. Yes; I would be very happy to.

Mr. FUQUA. Mr. Washom, the parabolic dish technology is relatively inexpensive to develop. Why can't that development be carried on by the private sector?

Mr. WASHOM. Well, I think, first of all, the premise that it is inexpensive to develop is correct in comparison to many of the other technologies, particularly central receiver. That is due to its modularity.

However, in the program right now we are pressing the state of the art in four different areas. Primarily the materials we can use at the focal point is at a 20,000 sun heat flux—16,000° Fahrenheit—which is pressing the state of the art of known materials.

Second, we have a tremendous amount of work to be done in the reflective surfaces on parabolic dishes. Third, we have some heat engine development. Thankfully, most of that is being paid for by the automotive programs in both Brayton and Stirling engines. We also have system level test and experimentations that are required. All of these four items are of significant technical risks but offer a high payoff if successful.

I think in the parabolic dish industry we do have, and we are proposing, a number of opportunities that can minimize the cost of parabolic dishes.

As an example, the Dish Stirling Cooperative bid which we have just won is $2.9 million Federal contribution to which my small company is putting up $850,000 in cost-sharing.

Industry also advocates that on the small community projects we can leverage that money by using venture capital and taking advantage of the energy tax credits.

Therefore, yes, we are less expensive; however, the technical risks and the economic risks still remain for that program to the

point where I think industry in their cost-sharing right now is pressed to the limit of private investment.

Mr. FUQUA. This is a question for maybe you or one of the panelists. What is the current cost per square foot for heliostats and the parabolic trough collectors?

Mr. WASHOM. Speaking for heliostats at the present time with the present volume that is being produced, I am informed that it is approximately $250 per square meter for the heliostat.

Mr. FUQUA. That is not including the rest of the system, now.

Mr. WASHOM. That would be equivalant to $25 per square foot for the heliostats. At the present time, parabolic trough collectors are in the range for the collectors of from $12 to $17 per square foot.

Mr. FUQUA. Mr. Seielstad.

Mr. SEIELSTAD. That is correct.

Mr. FUQUA. All right. With a name like Fuqua, I learn not to get too offended with mispronunciation. I hope you will forgive me.

Mr. SEIELSTAD. You are forgiven.

Mr. FUQUA. EPRI, in a statement before the committee, recommends that a precommercial solar-thermal plant several times larger than the one at Barstow be built by DOE, the supplier industries, and the utilities in a partnership. Do you concur with that recommendation?

Mr. SEIELSTAD. Unfortunately, I haven't had an opportunity to see EPRI's submission to this committee, so I would find it difficult to comment on that until I had a chance to really study their proposal.

Mr. FUQUA. On page 7 of your testimony you state that the change to a generic R. & D. emphasis would not serve the interests of the user community.

Mr. SEIELSTAD. Right.

Mr. FUQUA. I am paraphrasing your statement. Would you elaborate on that? DOE has proposed that they just do that and that would be all. There would be no demonstrations.

Mr. SEIELSTAD. Right. I believe that the path that we have been on historically has been an appropriate one in that it administers to the entry of the technology into the commercial sector at the earliest possible time.

We do have the possibility here of seeing solar thermal central receiver technology enter the commercial realm in a 20-year period which is really quite unusual. It is typical for a major electrical generation technology to require 30 to 40 years to learn the R. & D. and the commercial phase. Therefore, I believe that the program which we have been on has been an appropriate one, and it does show the potential of having reached commercialization within the next decade. An emphasis now on materials R. & D. and so forth is not necessary.

That is not saying that there are not additional interesting problems to explore, but under a realistic era of reduced Federal spending, the emphasis should be on things like the repowering problem, of pushing ahead to reduce the risk.

Right now, we are at this position of having something like a 50-percent uncertainty factor in the construction of a repowered plant. That is simply too high for the vendors, the third-party ven-

ture capitalists, and the utilities to proceed with. Further study has an excellent potential for reducing that high level of risk to something that both the manufacturer and the venture capitalist end utility can accept, and proceed with the actual reconstruction of the repowered plant.

These kinds of areas need further Federal support, in my view.

Mr. FUQUA. Dr. Berman, in October of last year, I think it was, the photovoltaics advisory committee recommended that the following activities be continued: technology development to evaluate research results, test experiments at the residential, utility, and intermediate level; balance-of-systems development; and testing and standardization activities. Do you concur with those recommendations?

Mr. BERMAN. Not completely. The area, I think, where there is a disagreement between what I have testified to and those recommendations has to do with technology development.

It is my feeling and the feeling, certainly, of some members of the industry, that in the case of single-crystal silicon devices the industry is quite prepared to carry the burden at this time.

Mr. FUQUA. Yes.

Mr. BERMAN. We do not see the necessity for continued Government support. However, the other items which were on the recommendation were, I think, all things which I alluded to in the testimony.

Mr. FUQUA. Yes; Thank you.

Mr. Fish.

Mr. FISH. Thank you, Mr. Chairman. Well, Mr. Berman, besides photovoltaics, do you believe that the Government Solar Center of Excellence should be responsible for the development of other solar technologies?

Mr. BERMAN. I believe it should be. Yes, sir. I think it should be responsible for several layers of solar energy.

Mr. FISH. Well, I think it is a very challenging idea.

Before Mr. Carter left office, he had a projection for a 20-quad contribution by solar out of 100 quads that we would be using by the end of the century. Does your sense of the contribution of solar come anywhere near that figure now?

Mr. BERMAN. My own personal opinion is that you can get within a factor of two of that, of the order of 10 quads.

Mr. FISH. Ten quads?

Mr. BERMAN. Yes; however, this requires doing a lot of hard work because there is not very much time left before the end of the century.

Mr. FISH. Further, Dr. Berman, this committee has spent a great deal of time looking into the merits of the SMUD project. Given our limited budget constraints, does the industry believe that it would be better to spend funds on utility-scale demonstration projects, or rather on more fundamental basic research that is consistent with the administration's energy philosophy?

Mr. BERMAN. I guess we ask for both. We think that the Sacramento Municipal Utility District is a somewhat unique situation in that it allows us a very early opportunity in a working environment to demonstrate the feasibility of photovoltaic devices for utilities. Therefore, we are recommending that program, but if you look

at our overall basis, you will see that we have recommended that something like three times as much money should be devoted to research as compared to that project.

Mr. FISH. Thank you.

Mr. Seielstad, the solar thermal central power concept—do I understand that the maximum megawattage which you envision is about 100 megawatts per unit?

Mr. SEIELSTAD. Studies indicate that the economic optimum module for solar central receivers is probably going to be around 100 megawatts—in the range of 50 to 100 megawatts. One would then duplicate that module perhaps on single site so you might ultimately develop 1,000 megawatts of capacity at a single site which would be broken into 10 modules coming on line for a period of years.

Mr. FISH. So it would be comparable to a conventional power plant today.

Mr. SEIELSTAD. Yes; it would.

Mr. FISH. You stated in your testimony, "The first milestone for Solar I has been completed." It would appear that the congressional investment of $120 million in the completion of Solar I will help us save the primary risks and uncertainties that exist today with this technology.

My question is, does the responsibility of the Congress extend beyond the 10 megawatts to even bigger projects or will industry pick these up?

Mr. SEIELSTAD. Well, I believe if the Congress supported the proposed STEA budget here to continue with the repowering program in particular and to provide the increased data base that the repowering program will provide, in addition to the increased data base that the operation of Solar I will provide, we then could arrive at the point of jumping off to have the risks sufficiently minimized so the third-party venture capitalists and the manufacturers and the utilities could begin to talk in terms of actual performance warranties of actual fixed price costs and proceed with the construction of major plants.

However, at this moment without extension of the solar tax credit and without further expenditures in the repowering program and other appetences to that, the risks are too high. Instead of the fulfillment which this technology has to offer, I am afraid it would be frustrated and stopped.

Mr. FISH. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Fish.

Mr. Gregg.

Mr. GREGG. Thank you, Mr. Chairman.

I was wondering, Mr. Berman, about the SMUD project. You want us to continue funding, I take it?

Mr. BERMAN. Yes.

Mr. GREGG. You wanted it at what level?

Mr. BERMAN. Well, our recommendation was $7 million, which was a direct request to go to phase II of SMUD. We are recommending an additional $3 million in support of the balance-of-systems programs that are essentially ongoing that would help that project—help the future of the project.

Mr. GREGG. Are you familiar with a report put out by the Aerospace Corp.?

Mr. BERMAN. No; I am not.

Mr. GREGG. Well, they concluded that this sort of project could be independently viable without Federal support as the result of the current Federal and State tax credits and the deductions for depreciation which we just passed. This sort of project could survive and be produced in the private sector with a 15-percent return after taxes.

I take it that you don't agree with that?

Mr. BERMAN. I am a simple-minded chemist, and you are talking too many numbers for me, sir. I just do not know.

Mr. GREGG. Is a simple minded chemist an oxymoron? [Laughter.]

Mr. BERMAN. Aerospace, I don't believe, has volunteered to finance this, have they?

Mr. GREGG. No; I wouldn't imagine that they have, but they are projecting that the possibility is there for it to be done.

You are suggesting that this is simply beyond the private sector's capability to undertake this?

Mr. BERMAN. Well, at the present, the SMUD project is a 100-megawatt program which extends for presumably another 12 years. We are asking the tax credits to get extended, but I think it takes a lot of vision into the future for someone to say, "Given these rules, it is economically viable."

Still, the first two stages of SMUD, based on the numbers I have seen, are not economically viable in and of themselves. It is the whole project which has to be considered.

Mr. GREGG. On another subject, the free-standing photovoltaic system, which is used in Saudi Arabia and I guess in some parts of the Southwest, when do you perceive that sort of a system will be competitive and viable in places that have an existing grid system?

Mr. BERMAN. Well, first, I cannot comment on the Saudi system because I don't know the details of it. However, our business is selling systems that are freestanding. That is the only business that our industry has today. They are economically viable.

You are saying, "When will they be economically viable compared to being competitive with grid?"

Mr. GREGG. Yes.

Mr. BERMAN. Except in special situations, in my own opinion, we have got a long way to go. That is why our recommendation is primarily to focus on research programs.

Mr. GREGG. Well, I take it that a country like the United States is probably going to have less of a market for them than an underdeveloped part of the world where there is no grid system.

Mr. BERMAN. Well, we sell our product where there is not a convenient connection to a grid today. We sell our product to places in the United States where there is not a grid connection or where the costs of running a wire are more expensive than our cost. That is our business.

It turns out that over the last year or two we have actually surprised ourselves. We are selling more and more things to people in northern California and in Spain where homeowners do not have

grid. They are buying this product and using it for a self-standing power.

One of the most interesting things which has happened in our industry is the increase in sales of this product to what we call the residential sector.

Mr. GREGG. What do you think the cost per kilowatt is going to be 3 years from now for the free-standing photovoltaic system?

Mr. BERMAN. Installed cost or per peak cost or what?

Mr. GREGG. Assuming you are heating with another form of electricity, whatever your baseline——

Mr. BERMAN. Well, I like to think of this in terms of cents per kilowatt hour; that is something I understand because that is how I pay my electricity bills.

Mr. GREGG. All right.

Mr. BERMAN. At the present time, we are probably of the order of 50 cents to $1 a kilowatt-hour system cost depending on insulation conditions and a whole bunch of things.

I can perceive us being down by as much as a factor of two.

Mr. GREGG. So you may be at 25 cents?

Mr. BERMAN. Twenty-five to fifty cents. That is right.

Mr. GREGG. If that is the case, you don't anticipate any major breakthrough that is going to cut that even further?

Mr. BERMAN. In the next 3 years?

Mr. GREGG. In the next decade. Why don't we take the next decade?

Mr. BERMAN. Oh, you picked 3 years, sir. I am sorry.

Mr. GREGG. All right. In your foreseeable market future.

Mr. BERMAN. In my foreseeable future, very definitely, I think with an aggressive research activity with some help of the type I have described today, I think we will reach the point where our costs will be competitive in this decade.

Mr. GREGG. If that is the case, why wouldn't the private sector want to undertake it?

Mr. BERMAN. It is. The bulk of the money being spent on photovoltaic research today is being spent by the private sector. All we are recommending here is the way that we think the Government could help.

Everytime I go to Japan I say, "Wouldn't it be nice if my Government helped me in research the way the Japanese government helps Japanese companies."

Mr. GREGG. Thank you. I guess my time is up.

Mr. FUQUA. If you have another question, go ahead.

Mr. GREGG. That is all right, Mr. Chairman.

Mr. FUQUA. Mr. Berman, I have one final question. In reading your testimony, I did not detect that you had indicated any specific amount that should be allocated. There is about $27 million in the budget for advanced research and development. That is all. Do you think that is an adequate amount? You mentioned a lot of things that you supported.

Mr. BERMAN. No. I do not believe it is adequate. However, I deliberately did not go line item by line item——

Mr. FUQUA. No.

Mr. BERMAN [continuing]. As I explained. However, the $27 that is in the budget—our numbers actually come to $46 million if you total them, but they are not in the same categories.

Mr. FUQUA. I am speaking really for advanced research and development.

Mr. Berman, I am sorry, sir. I do not know what that means because the language and semantics are also beyond me.

Mr. FUQUA. Yes.

Mr. BERMAN. As I understand it, that language also includes some things that used to be called "technology development." It is hard to compare. That is one of the reasons I chose not to look at that.

However, we are talking about—I assume the SMUD thing is not in the administration's proposal, so we are talking about $39 million versus the $27 in terms of comparable items.

Mr. FUQUA. That would not, I don't think, include the SMUD project.

Mr. BERMAN. Yes.

Mr. FUQUA. We thank all of you very much, and we appreciate you being here this morning.

Mr. BERMAN. Thank you.

Mr. FUQUA. Our next panel is Jerry Birchfield, director, Technology Applications Laboratory at Georgia Tech; Bradford Mead, director of energy programs for Grumman International; Doctors Aden and Marjorie Meinel from the University of Arizona; and Mryon Nordquist, legal counsel for the Ocean Energy Council.

We will begin with Mr. Birchfield, We are very pleased to have you with us today and to receive your testimony. As we did with the previous panel, if you have a prepared statement and wish to submit it for the record, we will be pleased to include it in its entirety. If you could possibly summarize, that would help expedite the time.

We will have questions at the end, as we did with the previous panel.

STATEMENT OF JERRY BIRCHFIELD, DIRECTOR, TECHNOLOGY APPLICATIONS LABORATORY, ENGINEERING EXPERIMENT STATION, GEORGIA INSTITUTE OF TECHNOLOGY, ATLANTA, GA.

Mr. BIRCHFIELD. Thank you, Mr. Chairman, I would ask that you include our written testimony in the record and I would like to speak from some notes to summarize quickly our written testimony.

Mr. FUQUA. Thank you very much. We have made your statement a part of the record.

Mr. BIRCHFIELD. I am here today as the president of the Biomass Energy Research Association to make comments about the need for continued Federal support for the part of solar energy that is commonly referred to as biomass.

First, a moment to explain the association that we formed. This association is a group of 12 charter members distributed geographically around the United States from Hawaii to Georgia to Maine and to southern California. It includes universities, utilities, and a

healthy complement of small businessmen who are interested in further activity in the biomass area.

Let us back up a moment and look at what biomass is, because it is a different technology to different people.

First, biomass is a distributed resource, in different parts of the country it is a different kind of technology. For example, in the Southeast, the Northeast, the Lake States, and the Pacific Northwest it is what we commonly refer to as "the forest resource" or "wood". In the Midwest it is "crop residues"; in the arid lands of the Southwest and the high deserts to the West it is "arid land crops".

Currently biomass supplies about as much power or energy to the U.S. energy economy as does nuclear energy. It is a very old technology and because it is an old technology many people think that we do not need to do anything further to cause it to increase its share in the energy economy.

There are many new facets of the technology, though, that do warrant continued support. The ultimate potential of biomass is fairly significant. Someone mentioned the earlier Carter projections of 20 quads contributed by solar by the turn of the century; biomass will probably make up most of those quads.

The ultimate amount of biomass potential that can be achieved without harmful competition to fiber or food is probably five times to seven times greater than its current contribution, which would put it somewhere between 10 and 15 quads.

Why do we need a Federal research and development activity in biomass?

Biomass is a technology which is regionally distributed around the country and it is actually a family of technologies, no one of which is extremely large; many different technologies are involved in many different parts of the country.

There is no consistent concentrated supply of biomass; it is distributed. It is not like an oil field which has tremendously high benefit that in turn warrants the tremendously high development costs that are associated with bringing an oil field on the line.

Actually, biomass is a series of small technologies which represent small business opportunities; small as compared to Ford or General Motors or General Electric. Because it does represent a series of small opportunities, we are dealing with a segment of the economy which is not as sophisticated in terms of research and development in the private sector, nor a segment of the economy which is rich and can afford extremely large, high-risk, high-cost research and development activities.

Biomass potentials are long range in potential benefit. We now see about two quads of energy produced from biomass. That production comes from what we traditionally call "direct combustion": burning of wood in stoves, burning of wood in furnaces in industry to produce power. For example, most of the pulp and paper companies in the Southeast burn a large amount of wood to generate both steam and electricity.

The biomass opportunity justifies Federal investment because it is a labor-intensive industry. The investment in research and development by the Federal Government will result in small business

activities which will result, we think, in increased jobs in rural depressed farming areas or forestry areas of the United States.

The budget recommendation that we support is one that is, in fact, slightly larger than the budget this year, the budget as proposed by the President is considerably smaller. For example: The President's recommendation is somewhere on the order of $7 million; current budget is about $20.5 million; and we recommend about $24 million for research and development activity.

Our detailed budget explanation is included in the prepared remarks which we have entered into the record and I will not explain the budget recommendations line by line, but we do support a budget level at about what it was in this current fiscal year.

One final point that I think needs to be made about the biomass opportunity: that is, it is actually a high technology opportunity as opposed to the general concept of a very low-level technology activity. As an example, the potential benefits that may come from genetic engineering to produce new supplies of biomass, such as algae which produce petrochemical substitutes is a very high technology industry; it is a very high-risk industry, it is a very expensive undertaking. We think that these types of high-technology opportunities should be pursued by the Federal Government and that they will have direct economic benefit back into the economy.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Birchfield follows:]

PREPARED STATEMENT OF JERRY BIRCHFIELD

Good morning. I am pleased to have the opportunity to address the House Science and Technology Committee. I am Jerry Birchfield, President of the Biomass Energy Research Association, a non-profit education and scientific organization recently established to promote understanding of biomass energy, and the role of research and development in biomass' growth as a national energy resource. Our membership includes representation from universities, businesses and utilities. The principal thrusts of our association, which distinguish it from other renewable energy groups, are to provide a unified focus:

- to educate the general public, industry and public officials about the opportunities for a major energy supply derivable from the many biomass feedstocks abundant in our country;

- to identify and promote needed R&D to economically grow and harvest biomass feedstocks and to convert them into useful fuels and chemicals;

- to establish a technical information clearing house for biomass energy data and literature, accessible to researchers, potential users of biomass energy, and officials involved with formulating policies and R&D programs;

- to encourage efforts to sustain a reasonable, well-balanced

and consistent Federal R&D program in biomass energy.

My remarks today will cover briefly the reasons why we believe BERA is needed; the value and potential contribution of biomass energy, with specific reference to needed research areas to realize the fullest benefits; and a set of recommendations for what we believe would be a minimal Federally-sponsored R&D program.

The oft-used expression, "the silent majority," aptly describes the broad-based, grass roots nature of your constituents who have strong interests in the use of biomass energy. As you know, biomass use for energy is now in excess of two quads per year in this country--a level comparable to nuclear energy--and yet, because it is so decentralized, the public and policymakers rarely give it adequate consideration. The very strength of biomass industries are their close relationships between resource site and the marketplace. Because of this, biomass industries are, in general, smaller business, farm- and forest-oriented, and quite diversified. This pattern discourages developing strong, centralized, and unified representation as typifies say, electric utilities or oil- and natural gas-related associations. We believe that biomass energy development is too important to not have its story spread, the worth of proposed R&D assessed and prioritized, and the information transferred to educate society and promote its eventual contribution as renewable energy systems assume an increasing share of the national energy supply burden. BERA has

95-882 O—82——21

been formed to fulfill these roles.

The challenge is complex because of the wide range of biomass resources and the very different ways they may be used for energy. These include:

- wood burned to heat homes;
- wood wastes and residues used for energy in the forest product industries;
- agricultural residues used for on-farm energy;
- high growth rate plant crops from land- and water-based energy farms for liquid or gaseous fuels and chemicals.

One of the remarkable attractions of biomass energy is its availability, albeit in different forms, in virtually every region of the country. There are significant wood resources throughout the Northeast and Southeast, parts of the Upper Midwest and the Pacific Northwest; agricultural resources are naturally concentrated in the Midwest; we are now learning about very interesting biomass feedstocks that grow in the semiarid regions of the Southwest.

From a consumer's perspective, this means that biomass energy can be

supplied in virtually every section of the country from contiguous resources, thus minimizing high cost transportation and delivery systems; a major savings accrues and is an important feature of biomass energy supplies. A second important feature is the reliability of the energy resource. A farmer or industrial user can have control over his own energy destiny and not have to worry about potential fuel cutoffs or price rises resulting from political crises halfway around the world. This potential of biomass to help insulate us from energy supply interruptions is of national importance as well as benefiting the individual user. A third, also under-appreciated virtue of biomass relates to its ability to provide jobs. If a locality turns, for example, to using wood for energy rather than oil or gas, the money for the energy--and the jobs that go with this--stay in the area and are not exported to other states or other nations. This can be important in many depressed regions of our country, and particularly so in the rural areas where unemployment or underemployment represent long-standing problems.

Biomass Technology--Today and Tomorrow

I have spent some time pointing up what we see as significant reasons to support biomass energy. Let me turn now to a few words regarding the current state of the technology and to what will be the principal focus of these remarks--the need for an aggresive R&D program. Nearly all the biomass energy that is consumed today uses very tradition-

al sources and technology. The direct burning of wood and wood wastes is the most important of these but contributions are also made from the anaerobic digestion of animal wastes to make methane, the conversion of grain into ethanol for liquid fuel, and the gasification of wood and agricultural residues to produce low-BTU fuel gas. The feedstocks used in all of these are wastes or excess production of traditional crops. These are indeed important potential sources of energy and most of the gains in the use of biomass energy in the next decade or two will come from these. However, two points must be made. First, there are significant R&D issues which remain even in these areas. Furthermore, because of the decentralized and small-scale use of biomass, there is not an industry out there with the money or research expertise to perform this research. A few examples come to mind of this research agenda:

- improved wood stoves and furnaces for residential and commercial heating and process heat which will produce significantly less air pollution;

- improved small-scale harvesting equipment to make harvesting of fuel wood more economical on small wood lots;

- development of a better understanding of the science of gasification to allow manufacturers to design more efficient gasifiers for wood or agricultural residues.

We believe that DOE must take the lead in addressing these problems because the companies in the field are too small and too under-capitalized to do the more basic R&D themselves.

The second point is that these traditional biomass feedstocks and end-uses are limited in their ultimate impact. The debate that raged over "food versus fuel" with respect to gasohol development was perhaps overstated, but was symptomatic of a broader issue. Ultimately, what will limit this country's use of biomass energy is not the amount of corn or Douglas fir trees that we have, but our finite resources of high-quality farmland and potable water. There will always be demands for food and fiber that will lay major claim to these resources; the challenge is to develop biomass energy crops which can make best use of the available land and water and can utilize the lower quality land and water. This is a very exciting area with great potential for the future; grasses, arid land crops, aquatic crops and fast rotation tree crops all have been shown to be large potential sources of sustainable energy for this country. However, there is much R&D that is needed and a large part of the leadership for this R&D will have to come from the Department of Energy until the technical uncertainties are diminished to the point where private investment can be justified.

In addition to new biomass feedstocks there is much fundamental and long-term R&D needed on advanced conversion technologies. This R&D

will lead to conversion methods that can make new products--such as medium BTU gas--or use additional biomass resources--such as expanding anaerobic digestion to be able to work on agricultural residues. As another example of high risk, high payoff R&D we believe DOE should be funding, I would point to the largely unexplored potential of the genetic engineering revolution for producing new biomass energy feedstocks and conversion technologies.

All of this work is not only highly significant in the development of one of the richest of the renewable resources available to the U.S., but could be absolutely vital to other nations. Many developing countries, without their own fossil fuel resources or hard currency to pay for imports, are slowly going bankrupt. Yet, many of them are in the tropics where biomass potentials are the highest. Not only could our R&D provide them a new and stabilizing source of domestic jobs and energy, but it could open up whole new markets for export of American expertise and conversion equipment.

Needs for a DOE Biomass Program

We are convinced that many biomass energy R&D programs will bear fruit and will make contributions to our nation's strength within the next two decades. The Congressional Office of Technology Assessment looked independently at some of these issues just two years ago. They concluded that biomass could produce well over 10% of the energy

for this country by the year 2000, but that a strong Federal R&D program would have to play a key role. We are all aware, however, that technology development is only partially responsive to time priorities. It is estimated to take between 10 and 20 years for a developed technology to capture a significant portion of its intended market; and that is after the R&D phase is successfully completed. We must continue the starts that have been made in the DOE biomass R&D program and not sacrifice the future to short-term budgetary gains; we are asking for very small quantities of money from a Federal or even an energy perspective but we believe the R&D investment will pay off well for all of us.

BERA strongly recommends a $24 million program for FY1983 for the DOE Biomass Energy Technology. We believe this level, which is comparable to what is available in FY1982, is the minimum required to maintain a viable on-going Federal effort in this vital area of energy R&D. To do less is, literally as well as figuratively, to eat the seed corn.

We would divide the funding approximately equally between studies related to biomass feedstock production and those aimed at improving conversion technologies. More specifically, we support the budget shown on the following pages.

RECOMMENDED FY1983 BIOMASS ENERGY TECHNOLOGY BUDGET

A. Biomass Feedstock Production Research $12,300,000

1. Woody Biomass Feedstocks.....$4,100,000.

Research should be continued which was started in 1978 to increase yields of woody biomass feedstocks by factors of two to eight over conventional forest industry production rates. Baseline annual yields at 27 existing experimental sites should be measured as a function of soil quality, fertilization, irrigation and cultivation techniques. Analyses and experiments must be conducted defining optimal growth rates of woody biomass, including the effects of geographic region, tree species, soil chemistry and type, silvicultural methods and frequency of coppicing. Research is needed in species screening, tissue culturing and hybridization techniques to explore genetic engineering approaches to increasing yields and resistance to disease.

2. Herbaceous Species Feedstocks.....$2,000,000.

Vigorous research is needed for high-yielding herbaceous and emergent/wetlands species crops, including grasses, canes, cattails, hydrocarbon oil-bearing species, etc., suitable for conversion to biomass fuels. Species screening and plant hybridization studies should be performed to identify highest-yield feedstocks growing on lands less likely to be used for conventional food and fiber production. Experimental plantings are needed at representative sites to identify the effects of soil, fertilization and other cultivation parameters. Genetic manipulation and engineering techniques for increasing yields must be explored. Analyses are needed to define conditions under which high yield crops can be obtained as well as to evaluate the possible environmental impacts of growing and harvesting

herbaceious and emergent species for feedstock production.

3. Aquatic Species Feedstocks.....$3,400,000.

These very promising experiments to grow and harvest oil-bearing microalgae from saline and brackish waters must be continued and expanded to establish baseline oil yields and to identify operating conditions under which yields can be increased, including the effects of water composition, flow velocity, nutrients, types of algae, and methods of harvesting. Research is needed to identify new species of oil-bearing algae and other aquatic plants and initiate breeding and other genetic manipulation techniques to maximize yields. Research results must be analyzed and evaluated to develop conceptual designs of second generation microalgae production experiments. Techniques should be developed for the on-shore production of several species of macroalgae. Finally, there is a need for a preliminary comparative assessment of the technical and economic potential of off-shore and on-shore macroalgae production methods.

4. Biological Production of Hydrogen.....$1,500,000.

This is very long-range basic research. We need to conduct species screening to identify bacteria and algae capable of producing hydrogen. Laboratory experiments should be performed, aimed at understanding the conditions under which these life forms grow, produce hydrogen, and reproduce, and genetic engineering experiments carried out to increase hydrogen yields.

5. Harvesting Technology.....$1,000,000.

Increasing the use of wood residues from our existing forests as well as making forests of fast rotation "energy trees" a reality, both depend on developing new harvesting techniques. Conceptual de-

signs and analyses of harvesting systems must be conducted for the economic retrieval of woody biomass. One or more concepts should be selected for detailed design, fabrication and testing under agreements with industry.

6. Supporting Feedstock Production Research.....$300,000.

Short-term screening procedures are needed to identify additional biomass species of high-yield potential. The screening procedures to be developed should aim primarily at identification of woody biomass species.

B. Biomass Feedstock Conversion to Fuels $11,700,000

1. Gasification and Pyrolysis.....$6,000,000.

This very promising area needs more support. Low-BTU gasification is nearing commercial reality but fundamental studies of physical mechanisms, efficiency and emissions are still needed. In addition, support is needed for the testing, analysis and evaluation of existing medium-BTU and synthesis gas process units and the results must be documented. Experiments should be initiated aimed at improving process efficiencies and reducing capital equipment costs, including identification of improved catalysts and improved reactor designs. Experiments should be conducted to define process conditions under which yields of petroleum substitutes from fast pyrolysis can be maximized.

2. Liquefaction of Biomass Feedstocks.....$1,500,000.

Laboratory-scale process research should be continued for the direct liquefaction of biomass feedstocks to explore the effects of different operating pressures and temperatures, catalysts, and car-

rier liquids. Process operating conditions that result in liquid hydrocarbon fuels of low oxygen content should be defined. Some conceptual designs of liquefaction systems should be performed to assess the technical and economic feasibility of processes as a function of capacity level, and to identify areas requiring more R&D.

3. Anaerobic Digestion of Biomass Feedstocks....$1,900,000.

Laboratory-scale experiments for the anaerobic digestion of cellulosic and agricultural residue feedstocks should be continued to explore and define improved digestor designs, pretreatments, micronutrients, extent of compaction and other operating parameters that result in greater production of biogas. Microorganisms must be identified which are capable of increasing biogas yields and explore their genetic improvement.

4. Supporting Feedstock Conversion Research.....$2,300,000.

A vigorous research program is needed to explore innovative physical, chemical, enzymatic and biological methods for the processing of biomass feedstocks to increase yields of fuels. Basic studies of biochemical and thermochemical conversion phenomena are urgently needed. Finally, research should be continued to evaluate and mitigate the environmental impacts of biomass feedstock conversion processes.

TOTAL OPERATING BUDGET:
$24,000,000

Conclusion

The budget we propose above comes to $24,000,000 in operating dollars in FY1983. In addition we would recommend $1,300,000 in capital equipment funds be provided. It is a spare, technology-oriented budget with no funds for commercial activities or projects. It is a small fraction of the budgets being requested for other activities within the Department of Energy. We believe, given the potential of biomass for the future of this and other nations, it will be an exceptionally good Federal R&D investment and recommend it to you.

Thank you for your kind attention.

Mr. FUQUA. Thank you, Mr. Birchfield.

Mr. Mead, your prepared statement will be made a part of the record.

STATEMENT OF BRADFORD M. MEAD, DIRECTOR, ENERGY PROGRAMS, GRUMMAN INTERNATIONAL, INC.

Mr. MEAD. Thank you, Mr. Chairman.

I am Bradford Mead, chairman of the International Trade Committee for the Solar Energy Industries Association. With a membership of around 900 members, SEIA represents more than 90 percent of the known domestic manufacturers in this country.

I am also director of the international energy programs for the Grumman Corp.

Mr. Chairman, export markets are very important to the American solar industry. In 1979 the solar industry exports totaled about $23 million. In 1980 the solar industry exported about $36 million. The leading export segment was photovoltaics with about 70 percent of the total sales.

We are doing pretty well at the moment. How well we do in the future is open to question. Our U.S. businesses pay monetary penalties to do business overseas; other nations are giving very strong support to their export development activities.

The French, the German, and the Japanese Governments have been donating solar demonstration systems to potential market areas. They are spending vast amounts on research and development to produce solar technology products appropriate for the developing nations. In addition, many governments have financed large national pavilions for use at international energy trade shows. These activities tend to put domestic suppliers in a serious competitive disadvantage. Moreover, the number of overseas markets that the American industry is capable of addressing is limited for three main reasons:

One, there is an insufficient amount of capital available for the investment in the development of overseas markets;

Two, there is a lack of understanding by U.S. solar exporters as to how to develop these markets; and

Three, there is a lack of suitable solar energy products appropriate for developing nations.

U.S. firms competing with foreign government subsidization of marketing and product development costs have been forced to make price reductions to stay competitive. This had led to reduced profitability and capital available for future investments, which is particularly limiting for small and medium-sized firms.

In an industry where the technology is constantly changing, where the markets addressed are often new to the companies and new to the technology, the costs inherent in market research and development seriously impact the ability of U.S. manufacturers to remain price competitive.

In 1980, 85 percent of overseas photovoltaic shipments were made by United States-based organizations; the remaining 15 percent coming from companies in Europe and Japan. That is changing.

Recent moves being made by the European and Japanese manufacturers and governments would indicate that the percentage of shipments from non-United States areas will tend to increase rapidly as the 1980's progress.

The increasing number of joint ventures being started in non-U.S. regions by U.S.-based manufacturers would also tend to support this trend. Recent announcements by the French, German, Italian, and Japanese Governments would indicate that Government support for manufacturers in these regions will also be increasing.

Recently, the government of Francois Mitterand in France announced a 10-year $38 billion program for renewable technologies. The French have already been formidable competitors. The additional impetus of a significant Government financial commitment will no doubt enhance the French market share in world markets. The EEC program to implement 15–18 pilot projects requiring approximately 1.3 MWP of photovoltaic modules in 1982 is a dramatic example of this increasing foreign support.

My concern is that the administration's proposed decreased level of support for renewable energy technolgies will assure the demise of U.S. manufacturers in the United States as well as world markets.

One Government program which attempted to alleviate some of the competitive disadvantages facing our industry in the international market was the international market development program sponsored by the Departments of Energy and Commerce last year.

During fiscal year 1981, the international market development program conducted a series of overseas trade shows and seminars which according to the recently released GAO report produced immediate sales of about $3 million and from which participants projected 12-month future sales of about $60 million.

The total cost incurred by the Department of Energy in sponsoring this program was about $500,000, a 100–1 leverage on the dollar. The return on investment clearly indicates the cost effectiveness of such a trade promotion event. When one takes into consideration that the total level of U.S. solar exports in 1980 was $36 million, the dollar volume potentially generated by this first trade promotion had the effect of almost doubling American export sales. The fiscal year 1982 budget eliminated this very successful program. But I am fully aware that this committee is on science and technology, and it is important to understand that when American companies have the chance through market development to go overseas and see firsthand what markets they could address if they had the appropriate research and development activities, combined with their Yankee ingenuity, to develop appropriate products for these markets and address them.

The concept of cost-sharing and the sponsorship of a joint industry-Government trade show had the most significant effect on middle and smaller size businesses who, for the first time, were able to participate in the international market.

Mr. Chairman, a reinvigorated market development program for renewable energy products, under the aegis of the Department of Commerce, would represent the single most cost-effective way to promote these products overseas. In addition, the leverage of each

tax dollar spent on such an effort will benefit our balance of trade and the growth of our industry.

The recommendations we would like to propose are the continuation of these export assistance programs conducted in fiscal year 1981 very successfully under the joint sponsorship of the Department of Energy and the Department of Commerce.

The program of overseas trade shows cost shared by industry and Government has resulted in significant sales for the U.S. industry with a total cost to the U.S. Government of $500,000. In addition, participants received valuable in-country marketing experience, increased contact with potential joint venture and license partners, and an understanding of where appropriate research and development opportunities might lie.

We would also propose the enactment of the export trading company legislation which is now currently pending and the establishment of an appropriate level of export financing at the Export-Import Bank.

We would also propose the participation by the United States in the funding of the proposed energy lending agency of the World Bank. While the development of Third World markets may be a private sector process, the inability of Third World countries to attain commercial financing because of their severe debt obligations to the commercial banking system necessitates a commitment to multilateral lending facilities. The perception of a U.S. commitment to the energy needs of the Third World is very crucial to the image of U.S. companies in the Third World.

We would also propose a commitment by the U.S. Government to participate in the international standards development for solar technologies. Foreign governments have made strong financial commitments to the development of their industries' position at meetings of organizations of the International Standards Organization. The failure of the United States to do likewise, once again, creates an impression that our Government is not committed to the development of the U.S. solar industry.

Mr. Chairman, in recent months there has been much said about the United States lagging behind other nations in innovation. Speaking for the solar industry, we do not intend to lag, we intend to lead.

The international market for solar energy systems is now wide open, but the competition is very keen. With your help, and the cooperation of the Departments of Energy and Commerce, we plan to capture a sizable part of that market for American industry. Thank you.

[The prepared statement of Mr. Mead follows:]

PREPARED STATEMENT OF BRAD MEAD

MR. CHAIRMAN, MEMBERS OF THE HOUSE ENERGY SUBCOMMITTEE, I AM BRAD MEAD, CHAIRMAN OF THE INTERNATIONAL TRADE COMMITTEE FOR THE SOLAR ENERGY INDUSTRIES ASSOCIATION.

WITH MEMBERSHIP OF AROUND 900 MEMBERS, SEIA REPRESENTS OVER 90 PERCENT OF THE KNOWN DOMESTIC MANUFACTURERS IN THIS COUNTRY.

I AM ALSO DIRECTOR OF INTERNATIONAL ENERGY PROGRAMS FOR GRUMMAN INTERNATIONAL, INC., A WHOLLY OWNED SUBSIDIARY OF GRUMMAN CORPORATION. WE ARE ONE OF THE LARGEST DOMESTIC MANUFACTURERS OF SOLAR HOT WATER SYSTEMS AND WE ARE ACTIVELY ENGAGED IN EFFORTS TO SELL OUR PRODUCTS OVERSEAS.

MR. CHAIRMAN, EXPORT MARKETS ARE VERY IMPORTANT TO THE AMERICAN SOLAR INDUSTRY. IN 1979, SOLAR INDUSTRY EXPORTS TOTALED $22.9 MILLION. IN 1980, SOLAR INDUSTRY EXPORTS TOTALED $36.1 MILLION. THE LEADING EXPORT SEGMENT WAS PHOTOVOLTAICS WITH 69% OF TOTAL SALES ($25 MILLION) FOLLOWED BY SOLAR HEATING AND COOLING 7% ($7.4 MILLION), WIND 3% ($1.0 MILLION), SOLAR THERMAL ELECTRIC 3% (1.0 MILLION) AND SUPPORTING PRODUCTS AND SERVICES (4%).

HOW WELL WE DO IN THE FUTURE, HOWEVER, IS OPEN TO QUESTION. WHILE U.S. BUSINESSES PAY MONETARY PENALTIES TO DO BUSINESS OVERSEAS, OTHER NATIONS ARE GIVING VERY STRONG SUPPORT TO THEIR EXPORT ACTIVITIES.

THE FRENCH, THE GERMAN, AND THE JAPANESE GOVERNMENTS HAVE BEEN DONATING SOLAR DEMONSTRATION SYSTEMS TO POTENTIAL MARKET AREAS. THEY ARE SPENDING VAST AMOUNTS ON RESEARCH AND DEVELOPMENT TO PRODUCE SOLAR TECHNOLOGY PRODUCTS APPROPRIATE FOR THE DEVELOPING NATIONS. IN ADDITION, MANY GOVERNMENTS HAVE FINANCED LARGE NATIONAL PAVILIONS FOR USE AT INTERNATIONAL ENERGY TRADE SHOWS. THESE ACTIVITIES TEND TO PUT DOMESTIC SUPPLIERS AT A COMPETITIVE DISADVANTAGE. MOREOVER, THE NUMBER OF OVERSEAS MARKETS THAT THE AMERICAN INDUSTRY IS CAPABLE OF ADDRESSING IS LIMITED FOR THREE MAIN REASONS:

1. THERE IS AN INSUFFICIENT AMOUNT OF CAPITAL AVAILABLE FOR INVESTMENT IN THE DEVELOPMENT OF OVERSEAS MARKETS.
2. THERE IS A LACK OF UNDERSTANDING BY U.S. SOLAR EXPORTERS ON HOW TO DEVELOP THESE MARKETS.
3. THERE IS A LACK OF SUITABLE SOLAR ENERGY PRODUCTS APPROPRIATE FOR DEVELOPING NATIONS.

U.S. FIRMS COMPETING WITH FOREIGN GOVERNMENT SUBSIDIZATION OF MARKETING AND PRODUCT DEVELOPMENT COSTS HAVE BEEN FORCED TO MAKE PRICE REDUCTIONS TO STAY COMPETITIVE. THIS HAS LED TO REDUCED PROFITABILITY AND CAPITAL AVAILABLE FOR FUTURE INVESTMENTS, WHICH IS PARTICULARLY LIMITING FOR SMALL AND MEDIUM SIZED FIRMS.

IN AN INDUSTRY WHERE THE TECHNOLOGY IS CONSTANTLY CHANGING, WHERE THE MARKETS ADDRESSED ARE OFTEN NEW TO THE COMPANIES AND NEW TO THE TECHNOLOGY, THE COSTS INHERENT IN MARKET RESEARCH

95-882 O—82——22

AND DEVELOPMENT SERIOUSLY IMPACT THE ABILITY OF THE U.S. MANUFACTURERS TO REMAIN PRICE COMPETITIVE.

IN 1980, 85% OF OVERSEAS PHOTOVOLTAIC SHIPMENTS WERE MADE BY U.S. BASED ORGANIZATIONS WITH THE REMAINING 15% COMING FROM COMPANIES IN EUROPE AND JAPAN. RECENT MOVES BEING MADE BY THE EUROPEAN AND JAPANESE MANUFACTURERS AND GOVERNMENTS WOULD INDICATE THAT THE PERCENTAGE OF SHIPMENTS FROM NON-U.S. AREAS WILL TEND TO INCREASE AS THE 80'S PROGRESS.

THE INCREASING NUMBER OF JOINT VENTURES BEING STARTED IN NON-U.S. REGIONS BY U.S. BASED MANUFACTUERS WOULD ALSO TEND TO SUPPORT THIS TREND. RECENT ANNOUNCEMENTS BY THE FRENCH, GERMAN, ITALIAN AND JAPANESE GOVERNMENTS WOULD INDICATE THAT GOVERNMENT SUPPORT FOR MANUFACTURERS IN THESE REGIONS WILL ALSO BE INCREASING.

THE GOVERNMENT OF FRANCOIS MITTERAND RECENTLY ANNOUNCED A 10 YEAR $38 BILLION PROGRAM FOR RENEWABLE TECHNOLOGIES. THE FRENCH HAVE BEEN FORMIDABLE COMPETITORS. THE ADDITIONAL IMPETUS OF A SIGNIFICANT GOVERNMENT FINANCIAL COMMITMENT WILL NO DOUBT ENHANCE THE FRENCH MARKET SHARE IN WORLD MARKETS. THE EEC PROGRAM TO IMPLEMENT 15-18 PILOT PROJECTS REQUIRING APPROXIMATELY 1.3 MWP OF PHOTOVOLTAIC MODULES IN 1982 IS ONE DRAMATIC EXAMPLE OF THIS INCREASING FOREIGN SUPPORT.

MY CONCERN IS THAT THE ADMINISTRATION'S PROPOSED DECREASED LEVEL OF SUPPORT FOR RENEWABLE ENERGY TECHNOLOGIES WILL ASSURE

THE DEMISE OF U.S. MANUFACTURERS IN THE U.S. AS WELL AS WORLD MARKETS.

ONE GOVERNMENT PROGRAM WHICH ATTEMPTED TO ALLEVIATE SOME OF THE COMPETITIVE DISADVANTAGES FACING OUR INDUSTRY IN THE INTERNATIONAL MARKET WAS THE INTERNATIONAL MARKET DEVELOPMENT PROGRAM SPONSORED BY THE DEPARTMENTS OF ENERGY AND COMMERCE.

DURING FISCAL YEAR 1981, THE INTERNATIONAL MARKET DEVELOPMENT PROGRAM CONDUCTED A SERIES OF OVERSEAS TRADE SHOWS AND SEMINARS WHICH ACCORDING TO THE RECENTLY RELEASED GAO REPORT PRODUCED IMMEDIATE SALES OF ABOUT $3 MILLION AND FROM WHICH PARTICIPANTS PROJECTED 12 MONTH FUTURE SALES OF ABOUT $60 MILLION.

THE TOTAL COST INCURRED BY THE DEPARTMENT OF ENERGY IN SPONSORING THIS PROGRAM WAS $500,000. THE RETURN ON INVESTMENT CLEARLY INDICATES THE COST EFFECTIVENESS OF SUCH TRADE PROMOTION EVENTS. WHEN ONE TAKES INTO CONSIDERATION THAT THE TOTAL LEVEL OF U.S. SOLAR EXPORTS IN 1980 WAS $36 MILLION, THE DOLLAR VOLUME POTENTIALLY GENERATED BY THIS FIRST TRADE PROMOTION HAD THE EFFECT OF ALMOST DOUBLING AMERICAN EXPORT SALES. THE FISCAL YEAR 1982 BUDGET ELIMINATED THIS VERY SUCCESSFUL PROGRAM.

THE CONCEPT OF COST SHARING IN THE SPONSORSHIP OF A JOINT INDUSTRY/GOVERNMENT TRADE SHOWS HAD THE MOST SIGNIFICANT EFFECT ON MIDDLE AND SMALLER SIZE BUSINESSES WHO FOR THE FIRST TIME WERE ABLE TO PARTICIPATE IN THE INTERNATIONAL MARKET.

MR. CHAIRMAN, A REINVIGORATED MARKET DEVELOPMENT PROGRAM FOR RENEWABLE ENERGY PRODUCTS, UNDER THE AEGIS OF THE DEPARTMENT OF COMMERCE, WOULD REPRESENT THE SINGLE MOST COST EFFECTIVE WAY TO PROMOTE THESE PRODUCTS OVERSEAS. IN ADDITION THE LEVERAGE OF EACH TAX DOLLAR SPENT ON SUCH AN EFFORT WILL BENEFIT OUR BALANCE OF TRADE AND THE GROWTH OF OUR INDUSTRY.

THE U.S. FREE ENTERPRISE SYSTEM DOES NOT ALLOW GOVERNMENT TO ALTER THE PROCESS OF NATURAL MARKET SELECTION BY BESTOWING FINANCIAL AND MARKETING BENEFITS ON A SELECT GROUP OF MANUFACTURERS HOWEVER, THE U.S. GOVERNMENT CAN TAKE EFFECTIVE MEASURES TO ASSIST THE U.S. ALTERNATIVE ENERGY INDUSTRY BY REDUCING SOME OF THE RISKS INHERENT IN CONDUCTING BUSINESS IN OVERSEAS MARKETS. WE STRONGLY RECOMMEND THAT THE U.S. GOVERNMENT ADOPT MEASURES THAT INCLUDE:

1. THE CONTINUATION OF EXPORT ASSISTANCE PROGRAMS CONDUCTED IN FY '81 UNDER THE JOINT SPONSORSHIP OF THE DEPARTMENT OF ENERGY AND THE DEPARTMENT OF COMMERCE. THE PROGRAM OF OVERSEAS TRADE SHOWS COST SHARED BY U.S. INDUSTRY AND GOVERNMENT HAS RESULTED IN SIGNIFICANT SALES FOR U.S. INDUSTRY WITH A TOTAL COST TO THE U.S. GOVERNMENT OF $500,000. IN ADDITION, PARTICIPANTS RECEIVED VALUABLE IN-COUNTRY MARKET EXPERIENCE, INCREASED CONTACT WITH POTENTIAL JOINT VENTURE AND LICENSE PARTNERS AND VALUABLE EXPERIENCE IN INFLUENCING THE FORMULATION OF RENEWABLE ENERGY INCENTIVES BY FOREIGN GOVERNMENT OFFICIALS.

2. THE ENACTMENT OF EXPORT TRADING COMPANY LEGISLATION

IT IS IMPORTANT THAT ANY EXPORTER UNDERSTAND HIS MARKET, HOW HIS PRODUCT MUST BE MODIFIED TO FIT THAT MARKET AND HOW TO REACH IT PROPERLY AND PROFITABLY. THE ADDITION OF THE BANKING COMMUNITY AS A PARTNER IN THE EXPORTING PROCESS WILL STRENGTHEN THE U.S. SOLAR INDUSTRY AND WILL RESULT IN THE DEVELOPMENT OF COMMERCIALLY SUCCESSFUL MARKETING STRATEGIES. IF THE U.S. SOLAR INDUSTRY IS TO REMAIN COMPETITIVE WITH JAPANESE, FRENCH AND GERMAN MANUFACTUERS, THE U.S. BANKING COMMUNITY MUST BE ALLOWED TO PLAY THE FINANCIAL AND STRATEGIC PLANNING ROLE THEIR FOREIGN COUNTERPARTS ARE ACCORDED BY THEIR RESPECTIVE GOVERNMENTS.

3. THE ESTABLISHMENT OF AN APPROPRIATE LEVEL OF EXPORT FINANCING AT THE EXPORT-IMPORT BANK FOR RENEWABLE ENERGY TECHNOLOGIES.

4. THE PARTICIPATION BY THE U.S. IN THE FUNDING OF THE PROPOSED ENERGY LENDING AGENCY OF THE WORLD BANK. WHILE THE DEVELOPMENT OF THIRD WORLD MARKETS MAY BE A PRIVATE SECTOR PROCESS, THE INABILITY OF THIRD WORLD COUNTRIES TO ATTAIN COMMERCIAL FINANCING BECAUSE OF THEIR SEVERE DEBT OBLIGATIONS TO THE COMMERCIAL BANKING SYSTEM NECESSITATES A COMMITMENT TO MULTILATERAL LENDING FACILITIES. THE PERCEPTION OF A U.S. COMMITMENT TO THE ENERGY NEEDS OF THE THIRD WORLD IS CRUCIAL TO THE IMAGE OF U.S. COMPANIES IN THE THIRD WORLD.

5. A COMMITMENT BY THE U.S. GOVERNMENT TO PARTICIPATE IN INTERNATIONAL STANDARDS DEVELOPMENT FOR SOLAR TECHNOLOGIES. FOREIGN GOVERNMENTS HAVE MADE STRONG FINANCIAL COMMITMENTS TO THE DEVELOPMENT OF THEIR INDUSTRIES' POSITION AT MEETING OF ORGANIZATIONS OF THE INTERNATIONAL STANDARDS ORGANIZATION. THE FAILURE OF THE U.S. TO LIKEWISE ONCE AGAIN CREATE AN IMPRESSION THAT OUR GOVERNMENT IS NOT COMMITTED TO THE DEVELOPMENT OF THE U.S. SOLAR INDUSTRY.

MR. CHAIRMAN, IN RECENT MONTHS THERE HAS BEEN MUCH SAID ABOUT THE U.S. LAGGING BEHIND OTHER NATIONS IN PRODUCT INNOVATION. SPEAKING FOR THE SOLAR INDUSTRY, WE DO NOT INTEND TO LAG, WE INTEND TO LEAD.

THE INTERNATIONAL MARKET FOR SOLAR ENERGY SYSTEMS IS NOW WIDE OPEN, BUT THE COMPETITION IS VERY KEEN. WITH YOUR HELP, AND THE COOPERATION OF THE DEPARTMENTS OF ENERGY AND COMMERCE, WE PLAN TO CAPTURE A SIZABLE PART OF THAT MARKET FOR AMERICAN INDUSTRY.

THIS COMPLETES MY PREPARED TESTIMONY, MR. CHAIRMAN. I SHOULD BE HAPPY TO ANSWER ANY QUESTIONS YOU MIGHT HAVE AT THIS TIME.

Mr. FUQUA. Thank you very much, Mr. Mead.

Now, Dr. Meinel, we are pleased to have you with us. Your prepared testimony will be included in the record.

STATEMENTS OF DRS. ADEN B. MEINEL AND MAJORIE P. MEINEL, UNIVERSITY OF ARIZONA

Ms. MEINEL. Thank you, Chairman Fuqua and other members.

I am Marjorie Meinel and I am a research faculty at the University of Arizona and a past member of the Solar Panel of the Office of Technology Assessment and also of our State of Arizona Solar Energy Research Commission.

Mr. MEINEL. I am Aden Meinel. I am a professor of astronomy and of optical sciences at the University of Arizona. We have both been involved in solar energy for quite a long time.

Ms. MEINEL. Ten years ago we first addressed committees of Congress on the prospects of solar energy as a possible important addition to the energy mix. It is interesting to see how our testimonies have changed over the years.

We began as strong enthusiasts who saw a bright future for solar energy, urging Federal support for this neglected field. We pointed out the great advantages to be gained, but emphasized a necessary condition—that it become economically competitive with other energy options.

After a decade of expanding Federal support of solar energy, it is appropriate to pause and look carefully at progress and see where future emphasis should be placed. We thus view the funding reductions in the congressional budget request for fiscal year 1983 as not necessarily bad for solar energy. Much money has been spent, and a vast spectrum of ideas have been carried through to the study phase, and many into the demonstration phase. Now we need to take a critical look into what actually has transpired.

We have reviewed two documents in preparation for this testimony: The Congressional Budget Request; and the Federal Energy R. & D. Priorities. We concur with the recommended points of emphasis in the budget but with minor differences.

The budget appears to protect the future science base for advanced solar technologies at a time when a reduction in Federal expenditures appears to be necessary for the well-being of the U.S. economy.

We feel that first-generation solar technology can be handled by the developing solar industry. Today, we think that as long as Federal and State tax rebates remain in force for solar installations that the industry will continue to grow.

It is important to note that solar is a capital-intensive energy supply; all the cost is front end. The economics of any solar investment depend on the interest rate on the money involved. Thus, high interest rates distinctly impact the solar industry. The downward pressure on interest rates from a reduced Federal budget deficit, therefore, should help the solar industry. The reduction in Federal support of commercially viable solar options will, through sharing the effort toward a balanced budget, thus be a positive contribution.

The cost of the energy derived from solar devices is of critical importance in the penetration of solar into the energy mix. In a scientific and technological sense, there are many successes from the DOE programs to date. The real question is, what prospect do they have of reaching cost goals?

Costs of solar options today show a curious dichotomy. DOE and its predecessors established cost goals against which to measure progress, for example, in photovoltaics, heliostats, and concentrators.

DOE can cite buys that appear to indicate they are on target, with their lowest small-lot buys reasonably matching their predictions. However, if we request price quotations from the same industry sources, but for commercial applications, there is a price gap that leads one to suspect that certain favorable prices were made to gratify those sponsors.

If the solar industry could offer the low costs achieved recently by DOE, then it could easily assume future commercialization of solar, and no further Federal support under the present budgetary stringencies would be necessary.

We feel that real costs indicate that further Federal support is still necessary in order to lower costs. This support is appropriate in the research as proposed in the budget because further gains depend on firming up the second-generation technology base.

We have reviewed the prospects and research needs in our written testimony, so I will skip over that in the spoken.

In conclusion there are five specific points that bear on the proposed funding and the Federal role in promoting utilization of renewable resources.

First, what are the principal barriers to investments in these technologies?

Investment will follow the market. There is a considerable market for solar hot water and active heating so long as the tax incentives remain. The market for process heat applications will be slow until the demonstrated price per Btu delivered is competitive. Investment in the supply side will closely follow this situation. Businesses are very cost conscious and conservative when a number of years is necessary to recoup costs. Thus, a solar purchase is viewed with caution.

In photovoltaics, the market will naturally broaden as price reductions are realized, as will investment in the production side. Again, it is important that tax advantages remain.

We do not think that the proposed reduction in support will necessarily affect investments in these technologies, which in any case will tend to wait until the market potential matches the price of conventional energy supplies. The main barrier has always been the capital-intensive nature of solar energy and the uncertainty of future energy prices.

Second, what Federal policies are needed to remove these barriers and encourage further development?

At this moment the Federal policy in place appears adequate to support orderly growth of the solar energy field. It should be reviewed each year and adjusted accordingly.

Third, to what degree can we rely on a decontrolled market to accelerate development of solar technologies?

A decontrolled market will certainly stimulate inquiry into the economic feasibility of turning to solar. In the past a price rise in a major segment of the energy mix has caused a similar rise in other sectors, followed by inflation. Thus, solar costs will also rise with decontrol. We doubt that decontrol will close the price gap between solar and other energy prices, but fear of uncontrolled energy costs may stimulate sales of solar.

Fourth, how successful have DOE programs been in aiding development and overcoming market barriers?

DOE programs provided an early market for some solar devices, such as solar cells, bringing down the price through volume production. Nevertheless, solar heating manufacture is so widely spread that total volume remains small for any one given manufacturer.

We think that the present solar market is developing rather unaffected by what DOE does from this point on. Future market development depends on a record of buyer satisfaction and verified performance claims.

Fifth, what do we anticipate will be the effects of terminating or significantly reducing DOE funding of these programs?

The short term effect will be small since the Budget does address what we see as the critical science base on which future technology will depend. Congress should carefully reassess these questions each year to see if demand or supply warrants renewed emphasis on solar technology. If the solar tax advantages were to be dropped the industry would face a crisis, even collapse of the market.

Continued progress in the key research areas can be continued by careful management of the budget request funds. Thank you.

[The prepared statement of both Aden and Marjorie Meinel follows:]

TESTIMONY: Aden B. Meinel and Marjorie P. Meinel

SOLAR RESEARCH AND DEVELOPMENT BUDGET, FY 1983.

Background Ten years ago we first addressed committees of Congress on the prospects of solar energy as a possible important addition to the energy mix. It is interesting to see how our testimonies have changed over the years. We began as strong enthusiasts who saw a bright future for solar energy, urging Federal support for this neglected field. We pointed out the great advantages to be gained, but emphasized a necessary condition -- that it become economically competitive with other energy options. We also drew attention to the serious impact of expensive energy on world prosperity. This was before the first Arab oil embargo. Today, a foretaste of this impact has already been felt in the rapid escalation of oil prices followed closely by all forms of conventional energy, and then by inflation.

A Pause After a decade of expanding Federal support of solar energy it is appropriate to pause and look carefully at progress and see where future emphasis should be placed. We thus view the funding reductions in the Congressional Budget Request, FY 83, as not necessarily bad for solar energy. Much money has been spent, and a vast spectrum of ideas have been carried through the study phase, and many into the demonstration phase. Now we need to take a critical look into what actually has transpired.

The Budget Request We have reviewed two documents in preparation for this testimony: 1) the Congressional Budget Request, Volume 2, Energy Supply Research and Development (hereinafter referred to as "Budget"); and 2) Federal Energy R&D Priorities, Report of the Research and Development Panel, Energy Research Advisory Board (hereinafter referred to as "Report").

We concur with the recommended points of emphasis in the Budget, but with minor differences as noted below. The Budget appears to protect the future science base for advanced solar technologies at a time when a reduction in Federal expenditures appears to be necessary for the well-being of the United States economy. The list of priorities sounds much like the charter for the role of SERI that we urged some years ago during discussions that surrounded its formation. We felt then and feel now that first-generation solar technology can be handled by the developing solar industry. Today, we think that as long as Federal and State tax rebates remain in force for solar installations that the industry will continue to grow.

Decontrol It is suggested in the Report that decontrol of all forms of energy will remove the need for tax benefits for solar, implying that a rise in energy costs will make the cost of solar competitive. The consumer will then turn to solar without the encouragement of incentives. There is a hidden fallacy in this argument. Because conventional energy sources affect the entire economy the cost of solar devices, too, will rise with decontrol and the gap will not close. The new solar industry needs continuation of tax incentives for the indefinite future. Without tax incentives there will be chaos in the solar industry.

Interest Rates It is important to note that solar is a capital-intensive energy supply -- all the cost is front-end. The economics of any solar investment depend on the interest rate on the money involved. Thus, high interest rates distinctly impact the solar industry. The downward pressure on interest rates from a reduced Federal budget deficit, therefore, will help the solar industry. The reduction in Federal support of commercially viable solar options will, through sharing the effort towards a balanced budget, thus be a positive contribution.

Solar Economics The cost of the energy derived from solar devices is of critical importance in the penetration of solar into the energy mix. In a scientific and technological sense there are many successes from the DOE programs to date. The real question is, what prospect do they have of reaching cost goals?

Costs of solar options today show a curious dichotomy. DOE and its predecessors established cost goals against which to measure progress, for example, in photovoltaics, heliostats and concentrators. DOE can cite buys that appear to indicate they are on-target, with their lowest small-lot buys reasonably matching their predictions. However, if we request price quotations from the same industry sources, but for commercial applications, there is a price gap that leads one to suspect that certain favorable prices were made to gratify DOE sponsors.

We recently encountered this problem in a proposed solar cold-storage project. Based on DOE buys we assumed the price could be in the range of 7 $/watt, but found that the price of cells alone was twice that figure. When cells were mounted into modules, the least usable unit, the price became 25 to 30 $/watt. This is the price that has prevailed over the past three years, yet the DOE goal in 1985 is 0.70 $/watt and this year it was to be already down to 2 $/watt. We thus view recent claims of buys being on the DOE target as ficticious prices.

There is a similar situation in regard to heliostat and point-focus concentrators. The claim of a reduction in price of heliostats in small lot buys by DOE from 45 $/ square foot down to 15 $/ft^2 does not agree with recent price quotations for proposed commercial installations of these devices.

If the solar industry could offer the low costs achieved recently by DOE then it could easily assume future commercialization of solar, and no further Federal support under the present budgetary stringencies would be necessary. We feel that real costs indicate that further Federal support is still necessary in order to lower costs. This

support is appropriate in the research as proposed in the Budget because further gains depend on firming up the second-generation technology base.

Prospects and Research Needs We will now evaluate a number of specific solar options in relation to the Budget and the Review.

Hot water heating: This is the most widely successful solar application, and the industry is adequately handling its progress. It can compete with 10 mil per kWh electricity but not yet with oil, coal or gas. However, cost increases in fossil fuels could broaden the market if such increases do not in themselves distort the economy and heighten inflation. This industry has benefitted little from Federal R&D support so reductions in the Budget will have little impact.

Prospects: good, with continuing tax advantages
Research needs: nil

Active heating and cooling: These two topics should be separated. Active heating is commercially viable at this time and no further Federal R&D support is necessary. Active cooling is still very expensive and is marginal. There is a very large potential market for solar cooling and appropriate industry efforts should carry this application.

Prospects: heating: good
cooling: doubtful
Research needs: nil

Passive cooling: The Report speaks favorably of passive cooling. We have worked intensively on the scientific basis for passive cooling and do not rate its prospects as highly. The problem is simple: rejection of heat to the night sky is effective in dry seasons, which is when nature itself does an excellent job of cooling and little

more is needed. In humid seasons when cooling is needed, nature does a very poor job. Even in Arizona where passive cooling should be the easiest for any state we were disappointed in the results of a project we did under state funding.

Prospects: dim

Research needs: nil

Thermal power systems: There is not much support for thermal power systems research in the Budget, other than in the important area of materials science. A one- or two-year de-emphasis of thermal questions would not be a serious delay, inasmuch as it would give time for careful assessment of the expensive demonstration projects now completed in this country and in several foreign countries.

Central receivers: The current cost of heliostats is close to the probable minimum. Costs incurred in balance-of-system still make a central receiver non-competitive with nuclear or coal power.

Prospects: dim for power

uncertain for process heat

Research needs: small, except as noted above

Small point-focus systems: The current cost of the concentrators is close to the probable minimum. Costs incurred in the balance-of-system still make small systems non-competitive as a power supply. JPL has recently reached a significant milestone with the first operation of a Stirling cycle engine of remarkable efficiency. This technology will not be ready for commercialization until the experimental results are in hand. Problems will probably be found that require further research in the areas of materials science that should receive Federal support. The funds that could be applied to this research appear to be thin in the Budget. This is one of the few areas in which we think additional budgetary support should be considered.

Prospects: dim for power except in remote areas
uncertain for process heat
Research needs: small, except as noted above

Linear focus systems: The current cost of trough-type concentrators is close to the probable minimum, but again there are significant balance-of-system costs. Many demonstration and commercial projects of this type have been completed. The industry is doing a good job of developing this solar option.

Prospects: dim for power
possible for process heat
Research needs: nil

Solar ponds: The Report speaks favorably of solar ponds. We think their effectiveness is over-rated and costs under-rated. Applications are probable only for large users. This concept is being adequately tested in projects in this and several other countries, but further development appears appropriate to industry.

Prospects: limited
Research needs: nil

Photovoltaic (silicon): The scope of possible processes leading to lower costs is well defined. Current costs may firmly resist downward movement at the module level. Their efficiency is near peak value. Many demonstration projects have been completed, and it is time to carefully assess their results. A commercial market of slowly growing size is developing.

Prospects: good in remote areas
poor in major electricity-use regions
Research needs: considerable, but addressed well in the Budget

Photovoltaics (sulfides): Problems of efficiency and lifetime are still much the same as over the past two decades of research.

Prospects: poor

Research needs: ill-defined, but addressed by the Budget

Photovoltaics (advanced concepts): Most of these options were foreseen in old concepts, but they are intrinsically expensive in terms of efficiency gains and are frought with materials problems. Fluorescent dye concentrators are also old and are still troubled by destruction of the dyes by sunlight.

Prospects: poor

Research needs: considerable, but addressed by the Budget

Electrical power storage: The importance of storage of solar electricity to the viability of these options is not reflected in the portions of the Budget we have reviewed. It is barely mentioned in the Report. The intermittant and unpredictable nature of sunshine affects the value of solar electricity. If a full standby conventional generating system is always needed to take over the full load dropped when sunshine is not available then the fuel saved is the only value attributable to the solar cells. This is a far lower value than if the solar component of the supply system had adequate economical storage. The assessment of progress, future points of emphasis, and support budget are not addressed in the portion of the Budget we have reviewed.

Prospects: unclear, but important

Research needs: unclear

Biomass energy systems (thermal): This ancient energy form is applicable in some areas -- even in arid regions, as demonstrated by our research into harvesting tumbleweeds and compressing them into "Tumblelogs."

Prospects: limited

Research needs: nil

Biomass energy systems (liquid and gaseous fuels): Interesting possibilities have emerged with good prospects for technological success, but the economics remain highly uncertain.

Prospects: unclear

Research needs: considerable, but addressed by the Budget

Thermal receivers and process subsystems: Efficient use of collected solar energy depends on the receivers and process subsystems. These have been explored at various locations under Federal support and by industry. Final economics, however, are limited by concentrator economics.

Prospects: unclear

Research needs: considerable, partially addressed by the Budget

CONCLUSIONS

In view of the above assessment of prospects there are five specific points that bear on the proposed funding and the Federal role in promoting utilization of renewable resources.

1) What are the principal barriers to investments in these technologies?

Investment will follow the market. There is a considerable market for solar hot water and active heating so long as the tax incentives remain. The market for process heat applications will be slow until the demonstrated price per Btu delivered is competitive. Investment in the supply side will closely follow this situation. Businesses are very cost-conscious and conservative when a number of years is necessary to recoup costs, thus a solar purchase is viewed with caution.

In photovoltaics the market will naturally broaden as price reductions are realized, as will investment in the production side. Again, it is important that tax advantages remain.

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We do not think that the proposed reduction in support will necessarily affect investments in these technologies, which in any case will tend to wait until the market potential matches the price of conventional energy supplies. The main barrier has always been the capital-intensive nature of solar energy and uncertainty of future energy prices.

2) What Federal policies are needed to remove these barriers and encourage further development?

At this moment the Federal policy in place appears adequate to support orderly growth of the solar energy field. It should be reviewed each year and adjusted accordingly.

3) To what degree can we rely on a decontrolled market to accelerate development of solar technologies?

A decontrolled market will certainly stimulate enquiry into the economic feasibility of turning to solar. In the past a price rise in a major segment of the energy mix has caused a similar rise in other sectors, followed by inflation. Thus solar costs will also rise with decontrol. We doubt that decontrol will close the price gap between solar and other energy prices, but fear of uncontrolled energy costs may stimulate sales of solar.

4) How successful have DOE programs been in aiding development and overcoming market barriers?

DOE programs provided an early market for some solar devices, such as solar cells, bringing down the price through volume production. Nevertheless, solar heating manufacture is so widely spread that total volume remains small for any given manufacturer.

We think that the present solar market is developing rather unaffected by what DOE does from this point on. Future market development depends on a record of buyer satisfaction and verified performance claims.

5) What do we anticipate will be the effects of terminating or significantly reducing DOE funding of these programs?

The short term effect will be small since the Budget does address what we see as the critical science base on which future technology will depend. Congress should carefully re-assess these questions each year to see if demand or supply warrants renewed emphasis on solar technology. If the solar tax advantages were to be dropped the industry would face a crisis, even collapse of the market.

Continued progress in the key research areas can be continued by careful management of the Budget request funds.

These opinions are our own and should not be attributed in any way as an official statement by the University of Arizona.

16 March 1982

BRIEF RESUME

Aden Baker Meinel, Professor of Optical Sciences and Astronomy
Optical Sciences Center, University of Arizona.

Formerly first Director, Kitt Peak National Observatory, founding Director, Optical Sciences Center; consultant to USAF, ERDA and several industries. Awarded Ives Medal, Optical Society of America, 1980, for work including optical aspects of solar energy.

Solar research specialties:

1) selective surfaces for thermal systems
2) solar thermal power "farms"
3) impact of short term solar fluctuations on central receiver systems
4) solar grain drying
5) distributed solar thermal concentrating systems
6) formation of SERI, consultant to ERDA
7) low cost concentrator development (JPL)
8) passive cooling science and application
9) biomass conversion "Tumblelogs" (tumbleweed)
10) energy/GNP inter-relationships
11) member, various international solar committees

Marjorie Pettit Meinel, Faculty Research Associate
Optical Sciences Center, University of Arizona

Formerly member Solar Panel of the Office of Technology Assessment, United States Congress; formerly member Arizona Solar Energy Research Commission.

Solar research specialties:

1) solar energy history and problems in perspective
2) solar thermal power "farms"
3) energy/GNP inter-relationships
4) solar energy applications for less developed countries (LDCs)
5) passive cooling
6) solar cooking
7) solar grain drying
8) member, various international solar activities

Mr. FUQUA. Thank you very much, Dr. Meinel.

Mr. Nordquist, your prepared testimony will be made a part of the record at this point.

TESTIMONY OF MYRON NORDQUIST, LEGAL COUNSEL, OCEAN ENERGY COUNCIL

Mr. NORDQUIST. Thank you, Mr. Chairman.

My name is Myron Nordquist and our firm serves as legal counsel to the Ocean Energy Council. The Ocean Energy Council, in turn, is a broadly representative group of companies that is devoted to the commercialization of ocean thermal energy conversion, OTEC.

We appreciate the chance to appear before you and to consider the question of the authorization that is appropriate for fiscal year 1983 for OTEC.

The written testimony before you is responsive, we hope, to the questions that were posed to us in the letter inviting our comments today. In my oral commentary I would just like to focus on first the context, as we see it, in which you must decide your priorities, and, second the specific matters that relate to authorizations in 1983 for OTEC.

The Ocean Energy Council is mindful of the budgetary constraints and the need for this committee to use good judgment in deciding what methods are best to get the maximum from the money that you have available. We are aware of inflation, unemployment, the high interest rates and the temporary lull in oil price escalation, although I will add parenthetically that we do not see that as a problem that, in any sense, is going to go away forever.

We are, therefore, prepared to deal in the belt-tightening that is necessary as a practical matter. However, in the case of OTEC there is a need for selective U.S. Government support.

There are certain high-risk items that remain and in which the Department of Energy certainly has an appropriate role. This is certainly the case with respect to the cold water pipe and the type of heat exchangers, for example.

Our understanding is that the Senate Energy Committee has authorized level funding for fiscal year 1983. We assume that that means that although there are no line items in that action, that this would be $20.8 million for OTEC.

The industry group operates on the lowest common denominator of support, and I think it would be fair to say that that would be the lowest common denominator of OTEC support that the Ocean Energy Council would be able to endorse.

However, it is much more important to look at how the money is used than it is just to focus on how much money is available. The Ocean Energy Council would certainly endorse the statements of the prior speakers with respect to the importance of tax credits and the loan guarantee program in the case of OTEC.

For the OTEC program, the continuation of the Department of Energy activities with respect to commercialization via a pilot plant would be the highest priority that the industry would agree upon. We are not advocating support for sterile research and devel-

opment activities nor, indeed, for building up expertise outside industry that would not contribute to this commercialization activity. We would urge you to pay attention to what industry says; it needs commercialization. We think the investment bankers' point of view should receive a lot of attention and we think that if you are able to continue to give the support to OTEC for fiscal year 1983 in the same spirit that this committee in particular has supported in the past, we think that we can vindicate the confidence that you have put in this form of alternative energy.

I would be pleased to answer any questions that you have, Mr. Chairman.

[The prepared statement of Mr. Nordquist follows:]

STATEMENT OF MYRON H. NORDQUIST

Mr. Chairman:

My name is Myron Nordquist and I am a partner in the law firm of Nossaman, Krueger & Knox. It is a pleasure to testify before this Subcommittee today on behalf of the Ocean Energy Council which my law firm represents as legal counsel. In this testimony, the Ocean Energy Council is pleased to respond to the questions you addressed to us in your letter of March 9, 1982.

1. What do you see as the principal barriers to investments in OTEC?

At present, private financial institutions perceive OTEC as a technology never tested on a scale sufficient to project performance on the scale that is being proposed for financial support. Also the technology needs refinement in some areas. Therefore, high risk is a disincentive for financing even feasibility studies. Although OTEC fuel is free, the cost of initial plants is high, and OTEC is very capital-intensive. This cost and the risk can be offset through government policies such as tax credits, loan guarantees, and PURPA, but ambivalent attitudes towards stimulation of this type renders these policies difficult to measure and potentially counterproductive. OTEC is economic today in some locations, but in the view of the financial community, the aggregation of

risk offsets the attractive return on investment.

2. What Federal policies are needed to remove these barriers and encourage further development?

There are five elements which would offset the investment disincentives and encourage further development. First, the Department of Energy's OTEC program must be continued. This is the most important point. The cornerstone of the program, the pilot plant designs, must proceed in order to develop data which will attract private investment in one or more pilot plants. The industry has been unsuccessful in trying to move beyond the "seed money" in the absence of government cost-sharing. We believe that private investment will finance one or more pilot plants, provided the risk can be reduced as part of the general effort to support this technology.

Secondly, continued research into OTEC technology and advanced concepts will be a major consideration for financing institutions, both with regard to the projects they are financing, and with respect to all the potential they see in the future. The ambivalent attitude of the Department of Energy towards incentives to OTEC investments also reduces the possibility of private funding of these research items.

Thirdly, the retention and extention of the tax credits

is critical to private sector financing. The importance of the credits is summarized in the attached executive summary of a paper prepared by Nossaman, Krueger & Knox concerning all the renewable energy and conservation credits.

Fourthly, the loan guarantee authority established by Public Law 96-320, the OTEC Act of 1980, is essential to the commercialization of OTEC. The guarantees permit highly leveraged investments which improve the economic attractiveness of the venture.

Finally, the legal and political challanges to the Public Utilities Regulatory Policies Act of 1978 (PURPA) and the rules promulgated thereunder are vital aspects of market access and protection for qualifying facilities. We believe that PURPA and FERC's rules should be upheld in the courts.

3. To what degree can we rely on an uncontrolled market to accelerate development of OTEC?

Decontrol of domestic oil prices, and the phased decontrol of natural gas prices which may be accelerated, have not, and do not seem likely to have the impact once projected. OPEC's position has changed signifcantly, and oil prices are falling in the wake of the supply glut. In view of this, perceptions of the global energy situation have changed, unfortunately helped by U.S. policies dictated by budgetary

imperatives. What has not changed are the objective facts; there is an energy crisis. Long-term pricing is an important element, but long-term supply vulnerability because of insecure access and the depletion of the oil and gas resources is a far more severe problem.

4. How successful has the DoE program been in aiding development and overcoming market barriers?

The DoE OTEC program has been highly successful in aiding the development of OTEC and helping to overcome market barriers. The research done on OTEC-1, which was primarily a heat exchanger test facility, other heat exchanger work, bio-fouling and corrosion research, cold water pipe tests, energy intensive product research, etc. has been a success for two reasons. First, the Department of Energy has done a good job in implementing its program. The technology has been refined to a degree where pilot plants are now technically feasible and there is a serious prospect of private financial support. Secondly, the work done by DoE could not have been performed by the private sector alone for the reasons discussed earlier.

The DoE role cannot be described as having been successful if that is taken to mean that it is no longer necessary. On the contrary, there is much work to be done, in

particular the pilot plant program. The technology needs to be advanced to the point when a commerical OTEC industry is in place, or it appears that such an achievement is highly probable, so that responsibility can be transferred from the government.

5. What do you anticipate will be the effects of terminating, or significantly reducing DoE funding of the OTEC program?

The DoE OTEC program was being funded at an average annual level of $40 million up to FY 1981. Even at that level, there was much important potential work that was beyond the budget. In many cases, instead of a needed full-scale test, a scaled down version or a study was substituted. In other cases, ideas never left the drawing board or were scrapped because of lack of money. The OTEC program was always underfunded, and its annual budget should ideally be in the region of $85 million as authorized for FY 1982 by Public Law 96-320.

At the FY 1982 appropriated level of $20.8 million, it was necessary to restructure the program and important projects like the cold water pipe test may be cancelled or significantly altered. An additional "significant" reduction in program funding would result in further damage. The pilot plant

program remains the number one priority, but much support work is vital to that program, such as environmental ($500,000), technical integration ($825,000), design ($170,000), marine architecture ($125,000), power systems design ($150,000), and other work. Other technology support work is needed for the pilot plant projects, and to develop possible alternatives for the present and future. Private financial institutions will be attracted to OTEC investment if this work continues.

Termination of the entire program would definitely mean the end of the OTEC industry in the United States in our opinion. The Japanese are pursuing OTEC aggressively, Tokyo Electric having recently commenced operations of their experimental plant on Nauru. Very simply, the Japanese, the Swedes and the French, would capture the entire worldwide OTEC market including the U.S. islands in the Pacific and Caribbean. This would be a significant loss of export potential to U.S. industry and shipyards as well as a lost opportunity to create employment for U.S. workers.

Mr. Chairman, I hope you find these answers responsive. I would be pleased to answer any questions that you or your colleagues may have.

THE NEED TO RETAIN THE RENEWABLE ENERGY AND CONSERVATION TAX CREDITS OF PRESENT LAW

Executive Summary and Conclusions

1. Repeal of the renewable energy and conservation tax credits, particularly in combination with the massive budget cutbacks in the supporting programs in the Department of Energy, would result in the curtailment of a large number of projects, impede the timely development and expansion of the renewable energy and conservation industries, and result in damage to the economy by reductions in employment and exports.

2. The renewable energy and conservation industries represent a strategic infant sector of the economy. Even with present Government tax subsidies, this sector operates at an economic disadvantage with respect to both conventional domestic energy sources and foreign renewable energy and conservation competitors.

3. There has been no change in the circumstances that led to enactment of the credits in 1978 and 1980 such that the basis for their retention has been invalidated. The credits were passed because of a detrimental national dependence on imported energy. This dependence has not been significantly altered. Oil decontrol, the planned decontrol of natural gas, the establishment of the Strategic Petroleum Reserve, and emergency petroleum allocation regulations, do not reduce the need for fostering a renewable energy industry. Increases in oil and gas prices alone have not produced growth in the renewable energy and conservation market. Moreover, it is not reasonable to expect an infant industry to compete on a free market basis with an international cartel with the power to set prices at rates which will make market penetration of new products financially unsound. The Strategic Petroleum Reserve and emergency allocation regulations solve only short term management problems following import restrictions. They fail to address long term supply issues.

4. The replacement of the ADR depreciation system with the Accelerated Cost Recovery System (ACRS) will not increase the return on renewable energy investments. Also, while the new credit for incremental research and development expenditures is of some use, it is more important at this point to generate sales and production based on current technology. Moreover, because the renewable energy industry has already invested so heavily to reach the production stage, incremental expenses may be small.

5. Investors are willing to put their capital into a venture because of the expectation of profit. The greater the risk presented by a particular venture, the greater margin of profit the investor will require before it is willing to

make an investment. At the present time, investments in renewable energy and conservation projects tend to be of a high risk nature compared to other types of investments. As a result, they do not generally, standing alone, present investors with a sufficient margin of profit to attract the needed investment. The tax credits, in many cases, provide an additional margin of profit to eliminate this insufficiency.

6. The repeal of some or all of the renewable energy tax credits may not result in the net revenue gains predicted by the Treasury after economic (e.g., employment) consequences are taken into account.

7. The Administration's previous statements supporting the credits, reliance on their continued existence as a basis for Department of Energy cutbacks, and explicit Administration recognition that the credits are effective, are inconsistent with proposals to repeal some or all of the credits. Reliance on Administration statements led to support by companies for the Administration's economic program.

Mr. FUQUA. At this time I will recognize the gentleman from New Hampshire if he has any questions.

Mr. GREGG. Thank you, Mr. Chairman.

Mr. Mead, I was wondering, you went through a list of things that you want the Federal Government to do in order to export photovoltaics. They included a joint trade show participation—is that what it was?

Mr. MEAD. Right. What we have proposed is reinstatement of the very successful program that occurred in fiscal year 1981 between industry and a combination of the Department of Energy and the Department of Commerce, where there is a joint-funded trade development program where industry funded part of it and the Department of Energy, through Commerce, funded part of it. It introduced American industry overseas to places where many of them had never been before.

Mr. GREGG. How much do you feel that will cost?

Mr. MEAD. We are recommending $2 million.

Mr. GREGG. Then you wanted the Export Trading Act passed which will not cost the Federal Government any money, right?

Mr. MEAD. That is correct.

Mr. GREGG. Then you wanted the Import-Export Bank funded. At what level do you want that funded?

Mr. MEAD. I would have to check the numbers on that. I am not familiar with that area.

Mr. GREGG. You wanted us to fund some sort of Third World lending process. What is that?

Mr. MEAD. Yes; this has been proposed at the Nairobi Conference in August, the World Energy Conference. It has also been proposed by the former World Bank head, Mr. McNamara.

It is, basically, a lending window by which Third World nations can go and get the financing for appropriate technology products and technology development from American industry. That funding level would have to be determined in light of the other World Bank obligations, but the issue at hand was to open up the window and to have it available.

Mr. GREGG. Do you know how much money is involved there?

Mr. MEAD. No; I would not be familiar with that.

Mr. GREGG. And you wanted us to participate in setting standards, is that what it was?

Mr. MEAD. That is correct.

Mr. GREGG. Does that involve any Federal spending?

Mr. MEAD. That is a negligible amount of money.

Mr. GREGG. I assume you also want us to keep in place the tax credits which represent about $4 billion?

Mr. MEAD. Absolutely. That is, perhaps, one of the key areas. Obviously a strong American industry is much more able to compete overseas than a weak one.

Mr. GREGG. Well, does it not seem a little ironic to you that industry and the private sector should be coming to the Federal Government and asking us to participate in this way? I mean at a time when the Federal Government is supposed to be getting out of your hair—have you not asked us to get out of your hair in regulatory activity, and asked us to get out of your hair in taxation? Have you not asked us to get out of your hair in oversight? Now you are

coming to us and asking us to participate with you and spend money and, basically, bail you out overseas and through tax credits, correct?

Mr. MEAD. I think the word "bailout" is perhaps the wrong choice. The real question is whether we want to be able to compete in the long-term overseas or not and those decisions will be made in the next couple of years.

This country has funded very large programs in the research and development of technology such as photovoltaics to the point where we can now compete overseas if we were able to compete in a free-market basis. But we are not just competing against our counterpart companies; we are competing against their governments also. The establishment of footholds and the establishment of marketing channels and the technology base overseas will occur in the next 3 to 5 years. If we are there then we will be able to compete in the long run; if we are not, then we are going to be closed out. We are being closed out now by the Japanese, by the French, and by the Germans. The issue at hand in the budget, I believe, in Washington, is what can we do for the next 2 or 3 years in order to keep the budget as low as possible; I recognize that, but there is another concern. That is, what is our position going to be for the long term? If we are not willing to recognize that—the industry, at the moment, can continue to compete on a somewhat marginal basis, less and less each year, and eventually we will probably be closed out because we do not have the spending level, either in the research and development or the marketing areas, that other countries are spending. It is a question of whether we want a position for the long term or not.

Mr. GREGG. OK. Well, let us assume that we are going to run a $150 billion deficit and you want us to spend this money on these projects, would you recommend to us that we cut defense? That would have some effect on Grumman, would it not?

Mr. MEAD. I am not sure I want to comment on that, sir.

Mr. GREGG. Would you recommend to us that we cut food stamps, social security? What do you recommend that we cut? Or do you recommend that we run a $150 billion deficit?

Mr. MEAD. I think there is another way to look at it.

Mr. GREGG. Well, I am looking for that way, so I am interested.

Mr. MEAD. I think that we proved in 1981 that the expenditure, for instance, of $500,000 on market development produced somewhere in the order of a $50 million or $60 million return in 12 months. That is 100–1 leveraging. I think even under this current administration's economic scenario, that probably created enough jobs and created enough solid industry base in this country, or assistance to pay back that money.

Mr. GREGG. Well, we just leveraged out 750 billion dollars' worth of tax deductions, which are supposedly going to return to us significant amounts and now you are asking us to leverage out some more money on top of that?

Mr. MEAD. Yes, sir.

Mr. GREGG. Do we not, at some point, have to plug the massive gap in the dyke, or do we just accept the fact that we are going to run a huge deficit, force interest rates up, and make you uncompetitive anywhere in the world, including the United States?

Mr. MEAD. Obviously there has to be a balance. There is no question about that.

Mr. GREGG. It affronts me, quite honestly, that Grumman—well maybe you can take Grumman as an extension of the Defense Department—but Grumman is a private sector company and it happens to be, I think, a very good company. I have a Grumman canoe. It has gone through a tremendous amount of damage and I have had it for about 15 years and it is still running very well—looks like it has been run over by a tractor. But, it does affront me. I can understand the universities coming to us and expressing their interest, but I just cannot see how, in this economic climate, the private sector can come to us and ask for more.

What they should be doing is coming to us and saying, "we can do it on our own. We can accomplish this. You get that deficit down. You give us the low interest rates and we will accomplish it." But, for the private sector to come to us and say, "we need more", whether it is international competition or within the United States, I have not accepted that logic yet. Could you respond to this concern?

Mr. MEAD. Mr. Congressman, it is not a question that we cannot make it on our own. We can make it on our own in a somewhat slow and methodical fashion if we were able to compete in a free-market basis. It is one thing to open up a free market in this country and we will compete, obviously, from company to company on a free market basis; we cannot do that overseas in light of what other governments are doing for their industries. There is a limit to what we can do even in this country because of the form of Government that we have. We cannot go out and subsidize 10 companies and say, "you are going to be the export industry" which is what they do in Germany. We are never going to be able to do that.

But, at the same time, we do have a problem in that American companies export only 10 percent of their products overseas. We have never had traditional international distribution channels overseas and this is an area where we have begun and become quite successful and, I think, the foreign competition has seen that and they are taking moves now to try and stop that.

While I can understand the Federal deficit, at the same time we have a problem that in the next 3 to 5 years we will not have an international market if we do not get out there and compete. Fifty percent of the photovoltaic shipments today go overseas—American companies. Now, that sounds high but the number is getting smaller.

Mr. GREGG. Well, basically, the testimony of Mr. Berman, before your panel, suggested that you are going to have a vital market—in photovoltaics or other technologies—in areas that do not have a grid system to compete with.

Mr. MEAD. Correct.

Mr. GREGG. So, you are going to have to sell them overseas. It does seem to me, however, that American industry should be able to compete in that market without having the United States underwrite. Maybe I am wrong.

Mr. MEAD. Then we are competing not only against our counterpart companies overseas, but we are also having to compete with their governments.

Mr. GREGG. Well, U.S. industry has traditionally competed with other governments. Our Government has traditionally not underwritten international activity and we, as a Government, have always taken the position that it is not our job to do that. If the French, or the Germans, or the Japanese, or the Swedes wish to socialize their industry, that is their decision, but our decision is that the private sector makes the competition, and our ability to compete internationally has always been our Yankee ingenuity, as you pointed out.

I just suspect that our Yankee ingenuity will maybe not survive in this area, but we will find another area where, in the international marketplace, we will dominate. As long as we allow it to do so in an economy which is not stalled out, that is our problem.

Thank you.

Mr. FUQUA. Mr. Volkmer.

Mr. VOLKMER. I would like to ask any member of the panel, does the temporary—and I call it temporary—decline in the price of oil have any effect on the alternative energy sources, solar, photovoltaics, et cetera.

Anybody who wants to may go right ahead and start.

Mr. NORDQUIST. Perhaps I can begin, at least by saying that at least in terms of OTEC, our problem is always time because it takes such a long time to get a project going, particularly at this time, the oil glut makes other alternatives look attractive, and it is difficult for us to get going now.

I think the long-term supply problem remains. We see it as a plateau now. The question of access to the resource is still with us and while it looks like a very good development, and indeed it is for our country in many respects that the price has leveled, for those of us engaged in long lead-time capital intensive alternative energy, I hate to say this, but it is a kind of drawback.

Mr. MEINEL. I think that the breather that is being given to us by this plateau in energy prices should be welcome at this time to get our economy in order and as a breather while we digest the very important results flowing from the programs that have been carried through to the demonstration phase. I think that it might be quite appropriate in future years to re-examine whether we make a renewed push, because certainly this is only a minor perturbation in the overall energy problem that we are going to face in the next several decades.

Mr. BIRCHFIELD. I think it is much too early to tell whether this recent decline which began, say in November of last year, is going to have lasting impact on the market. I think that one thing that the American economy, both private and public, during the last 2 years, is to be very skeptical about what the future price of any energy source is going to be except upward. So, I think there is a lot of caution that is used in judging this recent downturn and until it is with us for several years we will not believe the permanency of it and will not react toward some permanent lower level.

Mr. VOLKMER. I have no further questions, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Volkmer.

Mr. Nordquist, there has been some discussion about the recent OTEC pilot plant awards that DOE has made. What are your thoughts on the two awards that were made?

Mr. NORDQUIST. Mr. Chairman, I suppose it would not be a surprise to the committee to learn that those that were selected are not interested in any jeopardy of their awards, and those that were not selected are unhappy.

Our firm, in particular, happens to be on one winning team and one losing team. In the OTEC community there is that division that I mentioned.

The Ocean Energy Council will be addressing that question and we will be trying to see if there is some kind of uniform position on it, but at this stage there is a division of view about that issue, sir.

Mr. FUQUA. Has the Council come up with any recommendations for what should be in a base research and development program for OTEC for this year and what activities should be funded?

Mr. NORDQUIST. Yes, Mr. Chairman. I think the OEC could give you and your staff a detailed breakout on certain kinds of assumptions. We certainly, in the Ocean Energy Council, believe that the continuation of the pilot plant program and the very necessary high-risk research and development, such as the cold water pipe, need to be supported. We are not pushing for what we consider to be the kind of exorbitant activities' support that would be inappropriate for the industry. In the case of OTEC, on the razors edge of being commercial. Some activities are appropriate for the Federal Government, even in this situation.

Mr. FUQUA. Do you have any idea of funding levels?

Mr. NORDQUIST. We have indicated that, I think, the lowest common denominator of consensus on funding would be the $20.8 million that was recommended by the Senate Energy and Natural Resources Authorization Committee.

There are certainly members of the community, Mr. Chairman, that would want considerably more than that.

Mr. FUQUA. Dr. Meinel, you have mentioned, during the course of your statement, that a pause in Federal support for solar energy is not a bad idea. What concerns me about this pause is that it may disrupt ongoing work by laboratory and industry research teams and cause them to be disbanded. Should we ever decide to increase that level of effort, it might be difficult to reassemble some of those teams. I know that both of you do research and are familiar with what I am talking about—teams that work together and have been working together for some time. That causes me a little concern. My question is, what are your thoughts about that?

Ms. MEINEL. I will just start by saying that we know more about it than you would believe. We have lost more than most people in solar energy. Our last support was 2 years ago, I think, when we developed the tumblelog, made from tumbleweeds that we mentioned was an arid land resource. We have not received any since.

To begin with, SERI has already lost considerable staffing.

Mr. MEINEL. There has been a great deal of reduction in research, especially at universities already, but most people are flexible and move into other areas. I think that the total number of people that you are talking about is not too great to deploy them around within company structures, among other things, but it is all

predicated on the fact that we have got to cut somewhere. We have got a lot of very important demonstration projects to be carefully evaluated in their economic potential, so we said it was not necessarily harmful. If the Department of Energy is given some degree of leeway in deploying the moneys that are finally appropriated, I think they can still do a good job of protecting the essentials while we take this time to try to get the budget deficits in hand and do our share.

Mr. FUQUA. Of course, the Department of Energy budget has taken considerable reductions from what was being spent in fiscal year 1980 and even in fiscal year 1981. There has been concern expressed that we are now in an imbalance between nuclear, fossil, solar, other renewables and conservation. Do you have any thoughts about that?

Mr. MEINEL. On balance I cannot really say since I do not have overview of these others in the detail that I have in solar. But solar had a lot of heavy front-end money, like the Barstow project, which is now past the heavy funding stage. So, fortunately we are past those stages on it and we are anxiously awaiting the results.

But, the industry has been growing, and it will grow as long as these advantages that have been given to it remain in place. However, if they are dropped, as has been the recommendation, there would be utter chaos in the solar industry, and then the fears that you have expressed would really come about.

Mr. FUQUA. Where do you think the priorities should be, as we grapple with the issue of funding solar, between the large projects, like the Sacramento project or the Barstow project, versus some of the smaller, less capital-intensive projects?

Mr. MEINEL. Well, while our testimony of 5 or 6 years ago was to proceed with these large projects, you will note that our testimony also changed to support more smaller projects to give a broader sample of what is done. So, we definitely, at this point, would favor using available funds on modest-sized demonstration projects of the elements of technology that need to be firmed up so that the industry can then go forward with these new elements of technology. So, we favor more small elements.

Mr. FUQUA. What caused you to change your position?

Mr. MEINEL. Part of it is the study of some of the economics of large-scale solar electricity. You have to remember that you are dealing with an intermittent source of energy, and if you have to have in place all of the generating capacity of a conventional type to keep our electric grid fed, the only saving is the fuel involved; everything else continues, and that puts an extremely tight cost constraint on solar to be competitive if it is fuel prices only and not final, consumer prices.

The other part was our realization that some of these major studies, done by Aerospace Corp. and the Department of Energy as two examples, said the large, central power installations have a limited role of peaking power only when they could be online. So, this is one of the reasons why our thoughts have moved toward the smaller ones. We were especially impressed by the recent demonstration at the Jet Propulsion Laboratory with the Stirling cycle, of unusual efficiency, and we would like to see things like that continue. That is one of the areas, in our more detailed testimony, that we

thought more funds should go to to carry that demonstration program to a logical conclusion.

Mr. FUQUA. Mr. Birchfield, regarding the thermal and biochemical conversion activities currently being sponsored by DOE, why cannot industry pick up the tab for that development work?

Mr. BIRCHFIELD. Well, first of all, Mr. Chairman, it is expensive. As I tried to point out in my oral testimony, we are talking about a series of small business opportunities. We are talking about a group of technologists getting together with a group of venture capitalists and raising a few hundred thousand dollars and trying to tackle a problem that is probably worthy of several million dollars.

Gasification of wood, for example, was an area that for my organization in the Southeast considers to be a very important area of research. Except for an investment in research and development to the amount of about $1 million by the State of Georgia, gasification would not have proceeded to the point now where we have a large-scale test facility at a hospital in Georgia and a unit being installed in Florida Power & Light in North Florida.

Although we had a company in South Carolina which was small to medium sized, they were not willing to take the million dollar research and development risk to step into this marketplace. They were willing, though, in partnership with the State of Georgia and Georgia Tech, to step off into that void and now, we think and they think that they are seeing a market. This is some of the leveraging that Mr. Gregg was talking about.

If I might, I would like to add one comment to the discussion of international markets because it impacts also on biomass. There was a question about why the U.S. Government should be involved with domestic companies to encourage international marketing activities or research and development which might impact on the international market.

I would ask the committee to step back a moment and look at the agro-business sector. That sector in the U.S. economy has received a tremendous amount of research and development funds from the Federal Government over the past 50 to 75 years. The results of that program are very, very significant, both in the cost of food in the United States and the markets that the United States has been able to develop worldwide in terms of food. That happens to be our largest export area. I would submit that perhaps, there, the Federal investment developed the foreign market and simultaneously reduced the price of the food.

I manage now at Georgia Tech our international activities, and I am involved in the Philippines if I might for a moment just explain the situation that is happening there.

The Philippines were extremely interested in developing electricity from wood resources that they have and can grow in that country. They have been successful in obtaining a $125 million loan from the Asian Development Bank to install approximately 400 megawatts of wood-generated electricity. The French have supplied the Philippines with 10 electric power generators on a trade basis, basically, with the French Government assuming the risk. French private companies are moving into the sector to supply the technology, and we are concerned that the U.S. manufacturers will not be

competitive when the full purchase of about 1 billion dollars' worth of capital equipment will be made.

We think, for example, that in biomass, if research and development is done to work with these small and medium companies, they will be more competitive internationally.

Mr. FUQUA. Mr. Mead, we are spending about, or it has been proposed by DOE in the administration's budget to spend about, $10 million on a joint United States/Saudi Arabian project for fiscal year 1983. What are your views on this and the desirability to continue to fund this project?

Mr. MEAD. I think the project was a very important start in raising the level of world awareness as to what photovoltaics could do. It has been begun and it should, obviously, be completed. I think, beyond that, that it is history now that it has been started, and I feel very strongly that you want to complete it. Beyond that, I am not sure that there is an observation.

Mr. FUQUA. What are the merits of the project?

Mr. MEAD. I think that the project has demonstrated that photovoltaics has an application in foreign markets and I think that is a very important demonstration to do. I think you might look at future projects in a somewhat different light to see if you maybe want to break them down into smaller projects or have different types of applications, but I think it was very important in raising the world awareness to the fact that photovoltaics counted and they counted for overseas.

Mr. FUQUA. But have we finished the photovoltaic development part of it?

Mr. MEAD. Yes, sir.

Mr. FUQUA. Ms. Schneider.

Ms. SCHNEIDER. I would just like, for a moment, to pick up on the discussion of photovoltaics. It seems to me, from the testimony that I have been hearing before this committee for quite some time now, that we are going to be importing our photovoltaic technology with the high priority that this has been given by the Japanese, French, and others. Based on this particular budget proposal, it has become quite clear that the United States is no longer interested in photovoltaics. I wonder if I might get some response to that comment from some of you, or Mr. Mead if you have additional thoughts on it?

Mr. MEAD. I would be happy to start. I think that is exactly right. As I mentioned in my testimony, currently, of the total exports of any country in photovoltaics, 85 percent are coming from the United States. That number is going down very rapidly; the French are beginning to compete, the Japanese are beginning to compete and they are competing with very large government subsidies and support.

Our industry was the first to get started because we had a very large Government research and development program involved and some very large companies put a lot of their own money into research and development and we developed a generation of photovoltaics that began to compete with normal electric utilities.

At the same time, what other countries have done is taken what we have started and gone on to the next generations and have done massive funding programs in these areas and it appears as though

we are going to be stopping, and that is a problem. I think you are exactly right, I think we are going to become an import market in photovoltaics.

Ms. SCHNEIDER. Yes, Mr. Nordquist.

Mr. NORDQUIST. The comments are not limited to photovoltaics. In the last year, while we have been doing whatever we have been doing over at DOE, the French and the Japanese in particular have made great strides. Just as an example, the Japanese have built an operating OTEC pilot on the island of Nauru. There are many, many examples, across-the-board, which suggest we are going to have to decide in this country whether we are going to continue to look at the next 2, 3, or 4 years or whether we are really going to be concerned about the future. I am convinced that if we take the longer run look that there will be at least minimal modest support for the renewable energies, it has to come out that way.

But, we have the same problem in facing boards of directors that this committee has. They have alternatives and when you have a choice between putting your research and development money into defense programs or putting it into renewable energy, it is quite clear, in the present climate, that these boards of directors are going to be inclined to go with the priorities that are set by the Government. So, the tone and attitude of the Government is critical.

It is quite clear that, for the last year, in renewable energy other countries are putting their priority on it and we are not.

Mr. MEINEL. I would like to make the comment from the standpoint that I have seen some of these projects. We have seen some on our travels that, so far, are all loss leaders; they are not generating a profit for the companies involved. They are more for a show type of thing, that it is a popular thing. They have followed the lead that the United States has established over the past decade of pushing some of these technologies.

I think that the moment they become profitable for any companies involved, the American industry will move in very promptly and reestablish its position. As long as it is a guaranteed loss I do not think they will.

Ms. SCHNEIDER. I would like to follow up on that comment.

In my own State there are folks who are very much involved with what is often referred to as Yankee ingenuity in developing various types of solar systems or renewable resource energy systems. There seems to be a great desire to succeed and, in many instances, there are successes. My question is one that relates to big business versus small business. Your comment was that some of these industries, and you used the word industries which leads me to believe big, get into these projects for show. On that point, I am inclined to agree with you, that it is for show because if it were otherwise, do you not believe that the technology is there to move us ahead in photovoltaics, in biomass conversion, in OTEC, and in a number of other technologies?

Ms. MEINEL. You are right. The whole problem is which is the cheapest form of energy. Our American economical success has always been based on cheap energy as it is, in fact, in the world. The difference has been that in America we have had industry which was fueled by a cheap fuel; namely, the fossil fuels.

In other countries, Third World countries or developing countries, or LDC's, whatever you call them, they were based on cheap labor. This is the crux of the problem that we are facing today. I have heard it over the past several years said over and over and I heard it again today on several panels this morning, the statement that solar energy is a good thing because it can be labor-intensive; that is what makes it a bad thing. Whatever form of energy is labor-intensive then becomes an expensive form of energy. The cheap energy that we need to continue our particular system of economics——

Ms. SCHNEIDER. So your energy policy for the future would be to rely on nonrenewable resources; to use the coal and the oil and gas that we have?

Ms. MEINEL. I did not say that.

Ms. SCHNEIDER. That is what you were implying.

Ms. MEINEL. No; I said that in the past that has been what has given us a high standard of living, a cheap energy source. That is what we need in the future, a cheap energy source.

Ms. SCHNEIDER. You are saying that renewable fuels would not be cheaper?

Ms. MEINEL. May I first continue? May I finish my sentence?

Ms. SCHNEIDER. I want to make sure that I am following you.

Ms. MEINEL. In the past it was cheap energy that has given us a high standard of living; the more each man or woman can produce the higher the standard of living. In the past it has been the nonrenewable energy sources that have been the cheap energy source. In the future, if we can have a renewable energy source which is also cheap, we will then continue our high standard of living.

If you look at solar energy and say that you will always have to support it with some governmental funds, whether it is State, national or local, it is still not a cheap energy source because money is coming out of your pocket, but it is going in a different route to pay for it.

Ms. SCHNEIDER. Sort of like nuclear?

Ms. MEINEL. Yes; it is also a renewable resource.

Ms. SCHNEIDER. Someday, perhaps. Uranium is usually defined as a limited resource.

Ms. MEINEL. Well, by 1,000 years. I was thinking of the breeder. So, this is the point that we need a cheap energy source and supporting it by some form of taxation is still coming out of your pocket.

I would like to make a comment on your Yankee ingenuity. Yes, the solar industry that has developed has been more or less a small industry. Small in terms of the huge industries that have supported the energy field in the past. The life blood of that is the continuation of the tax situation that they enjoy at the present time to give them sufficient time so that they are directly competitive. So, yes, they have done a lot already in this area, but again, we cannot afford expensive energy. One cannot afford five times the present utility bill which could easily happen with an uncontrolled escalation of prices. So, at some point we are looking for the viable solar technology or fusion technology or safe breeder technology to provide us this low-cost energy supply that we depend on.

Ms. SCHNEIDER. Well, I am not going to comment on that because I am afraid we might be here too long and I do not choose to indulge the patience of the chairman.

I apologize for being late but I had another hearing going on.

Did you want to make a comment, Mr. Birchfield?

Mr. BIRCHFIELD. I wanted to get into the labor-intensive question because I do disagree with the Dr. Meinel in that area.

Ms. SCHNEIDER. That makes two of us.

Mr. BIRCHFIELD. Probably more than that, I guess.

I think that you have got to look at the basic cost of the resource and what it takes financially to move that resource from just a raw resource whether it is sunlight or a tree that is standing in the forest or cold water that happens to be 1,000 feet below——

Ms. MEINEL. Or tumblelogs.

Mr. BIRCHFIELD. Or tumblelogs. We do not have any of those in Georgia so I do not really know.

Ms. MEINEL. We invented them.

Mr. BIRCHFIELD. Good. You have to get inside of solar energy and look at the technologies before you can intelligently dissect the cost.

We have been involved a great deal in the wood source, the forestry source. We have looked at this issue quite a bit. We have got a resource in terms of wood, raw, standing in the forest in the Southeast, in the Northern part of your State, our State, all the way to New England. It is worth somewhere around $1½ a million Btu's per day. If you take that tree and make paper out of it, it is worth about a $1½ per million per Btu. You have got natural gas in the Southeastern part of the United States and I presume it is the same around the rest of the United States, selling somewhere between $4.50 and $6 per million Btu. There is significant opportunity to move that $1.50 per million Btu tree into a $5 per million Btu final product with labor, we can afford to do that.

The barrier that we face in the biomass technology area is the science to do that with. We have the rudimentary tools; we can gasify wood and we can produce a gas that will substitute for natural gas for about $5 per million Btu. Applied engineers in Florida Power and Light think the margin good enough to proceed. We see the solar resource, in general, as being a low-value entity, a low-value product, which through our labor and through our ingenuity can be turned into a more valuable product, and we do see it as being a worthy, worthwhile labor-intens.ve activity.

Ms. SCHNEIDER. Thank you very much. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Ms. Schneider and let me thank our panel for being here this morning. We appreciate very much your time and your statements and your answers to questions.

I wish we had simple answers for all of them.

Thank you very much and the meeting is adjourned.

[Whereupon the meeting adjourned at 11:43 a.m.]

1983 DEPARTMENT OF ENERGY AUTHORIZATION

WEDNESDAY, MARCH 17, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 1:50 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson presiding.

Present: Representatives Harkin, White, Volkmer, Nelson, Ottinger, Bouquard, Fish, Sensenbrenner, Gregg, Skeen, McGrath, and Walker.

Staff present: Dr. Martha Krebs, staff director; Dr. Eugene Frankel, science consultant; and Daniel M. Steinway, minority counsel.

Mr. NELSON. The subcommittee will come to order.

Today we will conclude our hearings on the Department of Energy fiscal year 1983 budget for conservation and renewable energy.

I would like to recognize Mrs. Bouquard, who will make some introductions with regard to the first panel.

Mrs. BOUQUARD. Thank you very much, Mr. Chairman.

Oak Ridge National Laboratory is world renowned for its programs in nuclear and engineering technologies, physical sciences, biomedical and environmental sciences, and fusion energy.

Less well known but potentially of equal importance is a new capability that has been developed at the laboratory over the past few years. That is the ability to perform analysis and computer modeling of energy consumption behavior in the different end use sectors.

Oak Ridge scientists and engineers have developed one of the most sophisticated computer models in the Nation for understanding where and how energy is used in our economy and how changes in prices, policies, and technologies are likely to affect that energy use.

The Oak Ridge model and its outstanding team of analysts give DOE a unique and powerful tool for making informed and rational energy decisions. Unfortunately, OMB seems bent on destroying that tool rather than using it for the purpose for which it was created.

The fiscal year 1983 budget proposal would virtually eliminate all analytical work in conservation and renewable energy and would reduce the analysis of energy markets and end use in EIA to

20 percent of its 1981 levels. These cuts, if approved, would decimate the Oak Ridge analytical effort.

Mr. Stockman also seems intent on ignoring the work that has already been done by the Oak Ridge team. Last year, for example, the Oak Ridge analysts found that DOE's conservation and solar programs could save the Nation more than $100 billion in imported oil by the year 2000. Yet OMB has deliberately chosen to eliminate most of these programs. I am appalled that DOE is supporting that position. This truly seems like a case of penny-wise and pound-foolish.

Today we have with us, Mr. Chairman, two of the more talented analysts at the Oak Ridge National Laboratory. Dr. Eric Hirst, a mechanical engineer by training, is an international expert in energy efficiency and has worked since 1970 in the areas of transportation and buildings. He is currently leading the group at the laboratory charged with evaluating the energy savings which have occurred to date in the United States economy.

Truman Anderson, a nuclear engineer, is director of program planning and analysis for the laboratory as a whole and is responsible for its strategic planning with a special emphasis on energy.

It gives me great pleasure to introduce these two gentlemen to the EDA Subcommittee today.

Mr. Chairman, I am sorry that I will have to leave and get back to my committee.

Mr. NELSON. I know you have to chair a committee yourself. We appreciate your introductory comments.

I would like to call on the ranking Republican, Mr. Winn.

Mr. WINN. Thank you, Mr. Chairman.

Today the subcommittee continues its hearings on the conservation and renewable resources portion of the Department of Energy's fiscal year 1983 budget request.

I found our hearings with the administration last week to be most interesting. I look forward to hearing the various views expressed by our outside witnesses today.

Our committee has been extremely interested in the past in the Department's conservation programs, as well as its programs for renewable resource technologies. I, for one, have found these various energy options to be particularly promising.

We have learned that the potential for efficiency improvements in the residential and the industrial sectors is enormous. However, without trying to oversimplify the situation, I think we all must agree that the greatest stimulus for the development and the commercialization of these technologies is to allow the market to set the actual value of our various fuel forms.

In accordance with this energy philosophy, the administration has called for a dramatic redirection in these programs. Long range, high risk, generic activities will now make up the corps of conservation and renewable resource activities in the DOE.

The Government's past role will now be taken over by the marketplace which will commercialize those conservation and renewable technologies that are economically viable. All of this is not to say that there is not an appropriate Government role in the study and the development of conservation and renewable resource technologies. This is the theme of our hearing.

However, I would also hope that our witnesses today can help us to decide what technologies the marketplace can pick up now.

Thank you, Mr. Chairman, for allowing me to make these remarks. I welcome the witnesses and look forward to their testimony.

Mr. NELSON. Thank you, Mr. Winn.

At this point without objection, Mr. Harkin's opening statement will be made a part of the record.

[The opening statement of Mr. Harkin follows:]

OPENING STATEMENT OF HON. TOM HARKIN

Today we conclude our hearings on the DOE fiscal year 1983 budget for conservation and renewable energy. Officials from DOE have been citing a study by their policy office which finds that less than five percent of the nation's energy savings since 1973 is due to DOE programs. This still amounts to a savings of more than $3 billion a year, not an insignificant accomplishment. But I think it is important to read the rest of what the author, Dr. Robert Marlay, had to say. I quote:

"This finding should not be unexpected. Many of the programs were not focused on the present or near-term, but on the longer-term future. Longer-term pay back, particular from R&D programs, may be higher."

And Marlay continues, "Having little effect on the whole does not mean that Federal programs are ineffective. Detailed cost-benefit analyses have shown that many of these programs are, indeed, cost effective, some more so than tax credits."

Marlay also finds that, "Curtailment of energy consumption, declining labor productivity, lower standards of living and slowed economic growth appear to be the predominant market response to higher energy prices. . . . Energy efficiency improvements, by way of capital investments have had secondary effects only."

The message from Dr. Marlay's study is clear: The marketplace alone will produce a lot of curtailment of energy consumption and only a little investment in efficiency improvements. I don't think that is the kind of energy conservation behavior that is desirable for the nation in the long-term.

Mr. NELSON. We would like to welcome Mr. Truman Anderson, Dr. Eric Hirst, Mr. Milton Copulos, and Mr. Ronald Wishart.

Gentlemen, please come up to the table. We will start with Mr. Anderson.

STATEMENT OF TRUMAN ANDERSON, DIRECTOR, PROGRAM PLANNING AND ANALYSIS, OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENN.

Mr. ANDERSON. First I would like to express my appreciation to the subcommittee for the opportunity to testify on the subject of what the country could afford to pay for research and development to improve the efficiency of energy use.

My comments today are based on a study we are doing at the Oak Ridge National Laboratory. It is an internal project, not sponsored by the Department of Energy, intended to provide guidance for us in choosing good research and development projects in the future.

The purpose, of course, is to understand research and development needs and priorities both on the demand side and on the supply side, of energy. One of the problems that you run up against is how to measure the benefits of research and development.

Our judgment is that the benefits should be social benefits that are recognizable as such by the mainstream of the American public. I believe many of the Nation's energy goals have lacked the kind of definition that most people can identify with.

For example, in the area of energy conservation I think saving energy is an especially poor goal that most people, including me, cannot quite identify with because there are so many ways to save energy, some of which are quite bad. A better goal would be to reduce the cost of energy service. I think most people can understand that a bit better.

Let me briefly comment on the five social measures that we have used in judging the benefits of R. & D. The first one is simply economic benefits.

The second one is reduction in environmental impact.

Third is reduction in health and safety.

Fourth is reduction in imported oil, a national security issue in my opinion.

The fifth is somewhat less tangible but nevertheless quite valuable. It is to provide the long term options that the country may need in the next 30, 40, and 50 years. These options should be quite different than the ones we have today so as to provide insurance against unexpected and maybe unpleasant happenings.

I will limit my remarks from here on to the economic benefits of improving efficiency of energy use.

In looking at that, it is interesting to consider what the country is now spending on end use energy forms. I am talking about gasoline and diesel fuel for the transportation sector, electricity, natural gas, and heating oil for homes and buildings, and electricity, natural gas, and oil for industry. What is the country paying for these end-use energy forms? The answer is about $400 billion dollars per year or about 15 percent of our gross national product.

In looking to the future we estimate that by 2020 the total energy bill will be something on the order of $900 billion. This increase by more than a factor of two is not strictly a result of increases in the cost of energy because the energy service during the period in our study increases very substantially. For example, the gross national product grows at 2.5 to 3 percent per year, the number of cars increases by a factor of two, and so do the number of miles traveled.

It is our judgment that, if we make good choices, the cost of energy service can actually be lower in 2020 than it is today, even without major technological breakthroughs.

If we look at the energy bill over the next four decades and ask what would be the lump sum equivalent right now of that bill, our estimate suggests something like $14 trillion, a very substantial sum of money. You get some feeling for the possibilities for research and development when you consider that a 1-percent reduction in the energy bill over the next four decades that would be equivalent to cash on the table right now of $140 billion.

What I am suggesting is that because the energy-cost number is so large even very modest decreases are worth a lot of money.

The question then is what could be afforded for research and development. To get an estimate we analyzed the end-use sectors. I do not want to mislead you into thinking that we did detailed technical and economic evaluations of all technologies across all sectors, but we did take a look at examples in each sector to try to get an understanding of what kind or improvements could be made in an evolutionary fashion, no huge breakthroughs imagined.

The conclusion that we drew is that, depending on the end-use sector, you could talk about a reduction in the cost of energy service up to about 15 percent of the energy bill. In our judgment, a 10-year R. & D. program could achieve something like this result.

What could you afford to pay per year for this improvement? If we require that each dollar spent on R. & D. return $10 of the benefits to society, then the answer is about $13 billion a year for R. & D. to achieve this fairly modest improvement.

I do not want the word "modest" to suggest that it is easy. It is not. It is much easier to get a 15-percent reduction in energy consumption than it is to get a 15-percent reduction in energy bill because you normally have to invest capital to reduce energy consumption.

I emphasize that the estimated allowable R. & D. expenditure is limited to the economic benefits of the end-use sectors. It does not include what could be justified for R. & D. to gain the other four social goals that I mentioned, nor does it include justifiable expenditures for R. & D. on the supply side.

It is also a national figure. It does not suggest what the Government should spend. It is what the Nation could afford to spend based on the opportunities.

It is fair to ask what the country is actually spending on research and development in energy. The numbers are not very certain but as best we can tell it is something like $7 billion per year in 1981 for all energy R. & D. The conservation R. & D. appears to be on the order of $1 to $2 billion per year.

I think that you can say we are spending far below what the opportunities say we could spend. Should we rush out and attempt to spend $13 billion a year for conservation R. & D? I think for several reasons the answer is no. Some of the reasons you know better than I.

A very important reason is that the country does not have the capability, the R. & D. capability, to efficiently spend that kind of money. We do not have the R. & D. managers. We do not have the R. & D. facilities. Nor do we have the researchers themselves.

If there is one thing that we learned or should have learned in the 1970's was that it is much easier to increase R. & D. budgets than it is to increase effective R. & D. Nevertheless, I think we should hold as a long-term goal the strengthening of the energy research and development capability of the country. I think it is extremely important that this be done if we are to be competitive in the world in the future.

The world energy demand, as many studies have shown, is going to be four, five, or six times larger 50 years from now than it is today. That means four, five, or six times the number of energy using devices. The world market is going to be quite large. Someone is going to get it. If we do not put our money on it, we are not.

What does this mean for the fiscal year 1983 budget? I think it is very important to keep in mind the long-term goal of building a strong research and development capability. The first consideration is not destroy what modest capability the country already has. That, in my opinion, should be the guiding light in formulating the fiscal year 1983 budget.

Thank you.

[The prepared statement of Mr. Anderson follows:]

POTENTIAL BENEFITS OF R&D DIRECTED TOWARD INCREASING THE COST-EFFECTIVENESS OF ENERGY USE

Truman D. Anderson

Director, Program Planning and Analysis
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

I wish to express my sincere appreciation for the opportunity to testify before the Subcommittee on Energy Development and Applications. We at the Oak Ridge National Laboratory are doing a study on energy R&D needs and opportunities to provide a basis for our internal planning. Although this work is not complete, I would like to share with you some preliminary results which, I hope, are both interesting and relevant to the budgetary issues you are trying to resolve.

Why Do Energy R&D?

It is our view that energy R&D should provide social benefits that are recognizable as benefits by the mainstream of the American public. Energy goals should be subservient to social goals — not the other way around. There is no *a priori* reason to assume, for example, that reducing energy use, developing the breeder, or producing a certain fraction of energy from the sun are good things to do. They may be good but, then again, they may not. The point is that energy goals need to be judged on the basis of societal benefits. We have chosen the following five social benefits by which R&D activities are to be judged:

- Economic Benefits. The market benefits realizable by society as a whole as a consequence of successful completion of an R&D activity.
- Environmental Benefits. The possible improvements in environmental indices related to air, land, and water.
- Health and Safety Benefits. Possible reductions of deaths, injuries, and disease.

- Energy Security Benefits. Reduction in dependence on imported oil within the next 20-25 years.
- Long-Term Options. Technologies in the formative stages that offer substantially different approaches to energy supply or end-use service in the long-term, and which are potentially acceptable on the basis of the preceding four attributes.

Although we are examining various areas of both energy demand and supply in relation to all the above attributes, I will limit my remarks to economic benefits from R&D on the demand side (i.e., energy end-use sectors).

Reference Level of Energy Demand and Cost

The benefits from energy R&D need to be separated from the benefits of non-R&D actions. For example, most people believe that many cost-effective improvements in energy use could be made using technologies already in hand. Actions directed toward accelerating this movement may be beneficial, but such actions are not R&D and it is not legitimate to ascribe the benefits to R&D. We were careful to exclude the non-R&D benefits from our study.

To get a measure of the economic benefits achievable from a technological innovation, we estimated potential savings from the innovation relative to a reference energy scenario which did not include it. The reference scenario was based on an earlier ORNL study* which considered energy supply and demand to 2020. This study assumed the use of available technologies or modest extrapolations of such. Thus, it formed a reasonable frame of reference from which the benefits of R&D could be judged.

*R. S. Livingston, T. D. Anderson, et al., A Desirable Energy Future, Franklin Institute Press, Philadelphia, PA, April 1982.

End-use energy demand levels for the reference case are shown in Table 1. The corresponding energy bills paid for end-use energy are given in Table 2. In 1980 we paid approximately $400 billion for energy distributed as follows: 39% for transportation, 35% for buildings, and 26% for industry. By 2020 the total energy bill is expected to increase to about $900 billion (1980 dollars) with 33% for transportation, 37% for buildings, and 30% for industry. Although industry will have the largest growth in energy use, the buildings sector will experience the largest growth in energy bill. It should be noted that the estimated increase in total energy bill reflects a very large increase in the level of energy service. Even without major breakthroughs in energy supply or demand technologies, energy cost per unit of GNP can decline if the country makes rational energy choices.

The present lump-sum equivalent of all energy bills over the next four decades is estimated to be about $14 trillion (1980 dollars) as shown in Table 2. To get some feeling for the economic opportunities afforded by R&D, let us suppose that a five-year R&D program could result in a 1% net reduction in the cost of energy over the next four decades. Further, let us require that each dollar spent for R&D must return $10 in benefits to society. What could be afforded for R&D each year for the five-year program? The answer is over $3 billion per year! The message is that even small improvements in the cost-effectiveness of energy use can justify significant R&D. The reason, of course, is that energy represents a substantial cost component of our economy, and even a small fraction of energy cost is still a large number.

Table 1. Energy to End-Use Sectors

End-Use Sectors	End-Use Energy (Quadrillion Btu/year) Actual[a] 1980	Projected[b] 2020
Buildings		
Space Heating	11.8	10.1
Water Heating	1.7	2.3
Lighting	1.0	2.1
Air Conditioning	1.2	2.7
Other[c]	2.3	3.8
Subtotal	18.0	21.0
Transportation		
Cars & Light Trucks	12.1	9.6
Medium & Heavy Trucks	3.5	5.4
Aircraft	1.6	3.0
Other[d]	2.6	5.9
Subtotal	19.8	23.9
Industry		
Feedstock	6.0	8.5
Process Heaters & Boilers	8.0	11.0
Other[e]	10.0	14.3
Subtotal	24.0	33.8
Total End-Use	61.8	78.7

(a)1980 information derived from EIA data.

(b)R. S. Livingston, T. D. Anderson, et al., A Desirable Energy Future, Franklin Institute Press, Philadelphia, PA, April 1982.

(c)"Other" for buildings includes cooking, refrigeration, food freezing, laundry, and miscellaneous appliances and entertainment devices. The first three of these uses accounted for half of the "Other" total in 1980.

(d)"Other" for transportation includes ships, trains, pipelines, buses, motorcycles, etc.

(e)"Other" for industry includes machine drive, electrolysis, on-site generation of electricity, road asphalt, and other miscellaneous uses. Up to one-third of this category (machine drive and electricity generation, especially) probably involves the generation of steam as a first step in the process.

Table 2. Total Cost for End-Use Energy(a)

End-Use Sectors	Estimated Energy Cost (Billions of 1980 Dollars) Actual 1980	Projected 2020	Present Worth of(b) Energy Cost 1981 to 2020
Buildings			
Space Heating	70	150	2700
Water Heating	12	34	500
Lighting	16	39	500
Air Conditioning	16	50	700
Other	24	66	900
Subtotal	138	339	5300
Transportation			
Cars & Light Trucks	102	137	2800
Medium & Heavy Trucks	26	74	1000
Aircraft	9	35	400
Other	14	55	700
Subtotal	151	301	4900
Industry			
Feedstock	20	60	800
Process Heaters & Boilers	25	99	1200
Other	56	110	2000
Subtotal	101	269	4000
Total End-Use	390	909	14,200

(a)The values shown represent the total cost of end-use energy forms delivered to consumers. For example, they include the total cost of gasoline (excluding taxes), electricity, natural gas to industry and buildings, etc.

(b)This represents the lump sum equivalent in 1980 dollars of all end-use energy bills over the next four decades. A discount factor of 3% (real) was used to get present worth.

Justifiable Expenditures for End-Use R&D

We examined each end-use sector to gain a better understanding of the magnitude of the potential savings to society that is possible through modest improvements achievable by R&D. It should be emphasized that we did not do a detailed technical and economic evaluation of all R&D opportunities across each sector. Rather, we looked at specific examples and from these results made judgements about the potential for broader opportunities.

It was judged that a ten-year R&D program could result in net savings of up to 15% of the end-use energy bill as shown in Table 3. Lest these percentages seem low, it should be remembered that a large reduction in end-use energy does not necessarily result in a large reduction in the cost of energy service. Saving energy usually requires an investment of capital; the figures in Table 3 are not values reflecting this tradeoff.

If it is required that each R&D dollar spent return $10 in benefits to society, it is our conclusion that the nation could justify spending over $13 billion per year over the next 10 years for R&D on the demand side of energy. It is emphasized that this is a national expenditure (not necessarily government) and that it is for market benefits alone. It does not include justifiable expenditures for R&D to gain other social benefits such as reduced oil imports, reduced health and safety risks, and a wider choice of options for the long-term. Neither does the estimate include supply-side R&D. Our estimates indicate that the potential supply-side benefits are of equal magnitude, but the benefits tend to be somewhat farther in the future than end-use benefits.

It is our judgement that the nation could probably afford to spend a total of around $20 billion annually (or about 5% of our total energy bill) for all aspects of energy R&D.

Table 3. Justifiable Annual Expenditures for End-Use Energy R&D

End-Use Sectors	Judgement of Net[a] Cost Reduction Achievable Through Modest Improvements	Justifiable[b] Annual R&D Expenditures (Billions of 1980 Dollars)
Transportation	15%	6.4
Buildings	10%	4.5
Industry	8%	2.8
Total for End-Use Sectors		13.7

[a]The estimated net reduction in the cost of energy service is expressed as a percent of the energy bill for the reference energy scenario.

[b]Assumes a ten-year R&D program which results in $10 of benefits for every R&D dollar spent.

In view of the size of the justifiable R&D expenditures, it is reasonable to ask what is actually being spent on energy R&D. Although available figures are not very precise, it appears that the country spent a total of about $7 billion on all energy R&D in 1981. Roughly half the total was funded by the private sector and half by the federal government. Our conclusion is that the nation is spending far less on energy R&D than it could justify spending.

Implications for the FY 1983 Budget

Simply because the country can justify spending $20 billion per year for energy R&D, does this mean that we should immediately try to spend that much? Most definitely not, for one simple reason: the nation does not have the energy R&D capability to efficiently use anywhere near the amount of funding that can be justified based on opportunity. We do not have the facilities, the researchers, or the experienced R&D managers necessary to take advantage of our opportunities in an effective way. We learned (or should have learned) in the 1970's that it is much easier to increase R&D budgets than it is to increase effective R&D; research and development cannot be switched on at will but requires time, effort, and patience to establish a strong national capability. But this should not deter us from the long-term goal of having a much stronger energy R&D capability than we have at present. For the present, we should avoid destroying the modest capability we already have. This, in my opinion, should be the guideline in formulating the FY 1983 budget.

Biographical Sketch
on
Truman D. Anderson

Truman D. Anderson is Director of Program Planning and Analysis at the Oak Ridge National Laboratory. He has responsibility for strategic planning with emphasis on energy.

Anderson received his undergraduate degree in mechanical engineering from the University of Missouri at Rolla and his M.S. in nuclear engineering from the University of Tennessee.

His professional experience has spanned a broad range of energy research and development activities including participation in the development of the world's first nuclear merchant ship and in research activities related to agro-industrial complexes for developing countries. Anderson's present responsibilities include energy analysis, and he is co-author of a soon to be published book entitled A Desirable Energy Future. He has served as a consultant and expert witness on energy at public hearings conducted by several government agencies.

Mr. NELSON. Dr. Hirst?

STATEMENT OF DR. ERIC HIRST, OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENN.

Dr. HIRST. Thank you.

What I would like to do is discuss several analyses that have been done by ORNL, including the one that Truman was just talking about, that relate to the past and present performance of Government conservation programs and the likely future benefits of conservation programs.

The reason I want to discuss more than one study is because this is a very complicated issue, as you know: What should be the role in the budget for Federal energy conservation?

Because it is complicated, it is valuable to look at this issue from a number of different perspectives, a sort of "triangulation" if you will. If the different approaches yield answers that are comparable, then you have some confidence in the results.

A study completed for DOE about a year ago was called the conservation strategy study. It sought to estimate the likely future impact to the end of the century of the then present (1980) set of DOE conservation programs.

That analysis did not take credit for legislative programs that were not part of DOE programs such as the tax credits and the corporate average fuel economy standard. It dealt only with the DOE conservation programs.

What that study suggested was a likely energy saving of the DOE programs in 1985 of almost three quads and a savings in the year 2000 of about 13 quads.

If you look at the reduction in oil consumption alone, that is ignore the other fuels, and do not look at the private benefit but consider only the incremental social benefit at, say $10 a barrel, you come out with a dollar saving of about $50 billion during the 1980's and 1990's. This would justify a budget of a couple of billion dollars a year for DOE.

Truman's study, that he just talked about, suggests a justifiable national R. & D. budget for conservation of about $13 billion a year, some portion of which should be done by the Federal Government.

These two and several other studies not done at ORNL suggest that there are large future benefits from Federal conservation programs, benefits sufficiently large to justify budgets of at least a billion dollars a year.

That is great, but talking about the future is somewhat fanciful so it is worthwhile also to look at the past and see whether the programs that have been in place during the last few years have provided benefits to society. There are two ways you can do that.

You can start from the bottom up and look at individual programs and assess whether those particular programs provided benefits in terms of energy savings and whether those energy savings are justified by the costs.

Unfortunately, there have been very few programs subjected to this kind of rigorous evaluation. On the other hand, those few that have, like the Energy Extension Service, the low-cost/no-cost pro-

gram, and utility RCS-type programs seem to be cost-effective. That is they provide energy benefits to the participant and the cost to run the program is more than offset by the dollar value of the energy that is saved.

An alternative approach is to look at historical performance by taking a top down approach to analyze aggregate national data and see what you can infer from that with respect to changes in energy consumption and the causes of those changes.

We did an analysis looking at the postembargo period—what has happened between 1973 and 1980. In 1980 energy consumption was about 22 quads below what it might have been if preembargo trends had continued.

While we consumed 76 quads in 1980, we were saving about a quarter of our energy. Another way of putting it is conservation contributed about a quarter of our energy budget in the year 1980.

Almost half of that 22 quads, that is 10 quads, was due to slower growth in GNP. We have had very poor economic performance the last few years. That is not really energy conservation or energy efficiency. That is really deprivation, doing without.

The remainder, 12 quads, can be considered an improvement in energy efficiency, partly due to technological progress—more efficient automobiles, higher efficiency motors in industrial facilities, attic insulation, and things like that. The other portion of that 12 quads efficiency improvement is operational changes—driving more slowly, turning down thermostats, et cetera.

Our analysis also tried to untangle the causes of that 12 quad energy efficiency improvement. What we come out with is roughly seven quads are due to price increases. That is the increases in energy prices over the last several years caused the free market system to cut energy consumption about seven quads.

What is left is about five quads. The analysis suggests that Government conservation program—probably not just DOE programs but other Federal programs and State and local programs as well as utility conservation programs—provided a savings of about five quads. That is an enormous amount of energy.

As I mentioned, you can probably only assign a small fraction of that savings to DOE. Nevertheless, it is worth an awful lot of money.

The final piece of evidence I want to discuss comes from DOE itself. The Secretary and Deputy Secretary have frequently during the past year talked about how much of the energy efficiency improvement is due to the private sector and have talked somewhat disparagingly about the likely benefit of DOE programs as being in the neighborhood of 5 percent.

Five percent of 12 quads comes to a savings of about $3 billion in 1980. It would be even greater in 1981. What I find difficult to understand is the disparity between the administration's recommended budget for conservation of $22 million and the benefit—according to their own figures—of about $3 billion. That is an enormous discrepancy. As I indicated, the studies that have been done at Oak Ridge looking both at the future and the past suggest a much larger impact for Federal programs.

My conclusions are that, first of all, conservation made a tremendous difference in our energy use patterns over the last several

years, yielding an energy saving of about 22 quads in 1980 and even more last year. Second, at least half of that savings was due to efficiency improvements, about 12 quads. About half of that 12 quads was due to technology improvements and about half was due to operational changes.

Evidence from a variety of sources, a kind of triangulation, suggests that Federal programs have in the past and are likely in the future to make a substantial contribution to those energy efficiency improvements. What that argues, at least for me, is that we really ought to continue funding a substantial Federal conservation program.

Thank you.

[The prepared statement of Dr. Hirst follows:]

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ENERGY DIVISION

ENERGY USE FROM 1973 to 1980: THE ROLE OF FEDERAL CONSERVATION PROGRAMS

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ABSTRACT

The role of federal (and other government and utility) conservation programs in reducing national energy use is an important, but largely unresolved, issue. This report develops simple econometric models of U.S. energy use; with gross national product, average energy price, and federal expenditures on conservation programs as explanatory variables. These models are then used to analyze changes in energy use between 1973 and 1980, and the causes of these changes.

Energy use in 1980 (76 Quads) was substantially lower than preembargo trends would suggest (by almost 22 Quads). Almost half of this reduction (10 Quads) was due to slower growth in economic activity. The remaining 12 Quads reduction was due to improvements in overall energy efficiency. The 1980 increase in energy efficiency was due primarily to rising energy prices (almost 7 Quads) and also to government conservation programs (almost 5 Quads).

1. INTRODUCTION

Energy use trends during the past few years were dramatically different from those during the 1950s and 1960s (Table 1). Spurred by rapidly rising fuel prices and occasional fuel shortages, energy efficiency* in the U.S. improved sharply.[1-3] Because of these recent changes, the value and importance of improved energy efficiency is no longer a major public policy issue; energy conservation is now widely accepted as a major contributor to resolution of our nation's energy problems.[4-11]

However, our understanding of the changes that occurred, the causes of these changes, and their manifestations is incomplete. The relative importance of changes in economic activity, fuel prices, fuel shortages, government conservation programs, and private (primarily utility) programs on energy use is difficult to determine. As a consequence, the debate continues on the appropriate federal role and budget for energy conservation programs.

An earlier ORNL report[12] analyzed changes in national energy use for the 1973-1980 period in each of the major sectors: residential and commercial buildings, transportation, and industry. The analyses dealt with two issues: what changes occurred in energy use during this period and why they occurred. Unfortunately, the models used in that analysis

*Energy efficiency is defined broadly to include all changes in energy consumption not caused by reduced economic output. Thus, efficiency includes the effects of capital improvements (technical efficiency) and operational changes.

Table 1. U.S. energy use trends, 1950-1980

Sector	Growth rate (%/year)		1980 energy use[a] (Quads)
	1950-1973	1973-1980[b]	
Residential/Commercial	4.5	0.4	27.4
Industrial	2.9	0.4	30.3
Transportation	3.2	0.1	18.6
Total	3.5	0.3	76.3
GNP growth (constant-$)	3.7	2.4	

[a]Electricity is treated in terms of primary energy (11,600 Btu/kWh) rather than end-use energy (3412 Btu/kWh) in this report. British units are used, primarily because the data were collected and reported in these units. Appendix Table A.1 gives conversion factors from British to SI units.

[b]Data for the first ten months of 1981 (see the January 1982 issue of the *Monthly Energy Review*, ref. 2) show that energy use declined between 1980 and 1981 by 1.6% for the residential/commercial sector, 2.9% for the industrial sector, 2.1% for the transportation sector, and 2.2% for the economy as a whole.

Source: refs. 1-3.

were not able to adequately identify the effects on energy use of government and utility conservation programs. The major purpose of the present study is to explicitly examine, in an aggregate fashion, the possible effects of these nonmarket forces. We do so by developing simple models of national energy use as functions of gross national product, average energy price, and U.S. Department of Energy (DOE) energy conservation expenditures.* These models are then used to explore

*We obtained estimates of the annual expenditures on energy conservation programs (research and development, information, outreach, grants, regulations) for the U.S. Department of Energy and its predecessor agencies (the Federal Energy Administration, Energy Research and Development Administration, and National Science Foundation) for fiscal years 1970 through 1980.

variations in energy use under different assumptions concerning the paths of GNP, energy prices, and federal expenditures during the post-embargo (1973-1980) period.

Section 2 discusses the theoretical basis for the models we developed. Section 3 presents our data and models. Section 4 presents results obtained from simulations run with the models. Section 5 discusses limitations in the present analysis and suggestions for additional research. The last section summarizes our findings and conclusions.

2. THEORY

Our primary objective is to analyze the relation between energy demand and federal conservation program expenditures. We assume that federal conservation expenditures serve primarily to facilitate the flow of information to both producers and consumers. Our approach specifies how energy demand and information are related at the micro-level and then proceeds to suggest an aggregate relation from the micro-model.

We assume that information is costly and that government conservation programs reduce the out-of-pocket costs of information. Information about, for example, more efficient energy-using durable equipment can result in investments that allow consumers to produce at the same level using less energy.

Whether it be from the perspective of a large manufacturer or an individual consumer, conservation information affects energy demand in two ways. One way is directly in the operation of energy-using equipment;

the other way is indirectly through its effect on future investments in energy-using equipment. Programs to advise consumers of such things as the benefits of thermostat setbacks or delamping are examples of direct effects of information. Indirect effects occur when a firm replaces equipment with new equipment that is more energy-efficient, or when a homeowner replaces an electric furnace with a heat pump.

In the remainder of this section we specify a micro-model of durable investment and energy use based on work by Dubin and McFadden.[13] We then use this model to suggest an aggregate model of energy demand related to government conservation expenditures. In this discussion "consumer" designates an energy consumer which may be either a firm or a household.

Suppose that a consumer can choose among n alternative (and mutually exclusive) portfolios of energy-using durables. Let the consumer's choice for a specified end-use be determined by his evaluation of the attributes and costs (including information costs) of each alternative and his income. We describe the consumer's evaluation of alternatives with an indirect cost function that depends on the alternative's attributes and costs, and consumer's income. Note that each alternative represents a different energy consumption possibility. If, through production cost information or feasibility information, government conservation programs convince consumers to choose energy-efficient alternatives, the program has facilitated the process of making energy use more efficient. Let:

K_i = 1 if portfolio i is chosen and 0 otherwise,

I = consumer income,

p_i^* = rental price of portfolio i,

p_1, p_2 = prices, respectively, of fuel 1 and alternative fuels,*

W_i = attributes and costs of portfolio i.

We can write the consumer's indirect cost function as:

$$c_i = \bar{c}(K_i, I-p_i^*, p_1, p_2, W_i) \tag{1}$$

The cost functions c_i describe the available alternatives. Once an alternative is chosen (suppose it is alternative k, i.e., i=k), then fuel 1's demand equation is determined by Shephard's lemma as $\partial c_K/\partial p_1$. This demand equation will be a function of the variables in the cost function; we write it as follows:

$$x_1 = \bar{x}_1(I-p_i^*, p_1, p_2, W_i) \tag{2}$$

To account for unobservables and differences in individual consumers, Eq. (2) is assumed to be stochastic. Dubin and McFadden[13] show that under certain assumptions we can write the expected demand for fuel 1 given that portfolio i was chosen, $E(x_i|K_i = 1)$, as follows:

$$E(x_1|K_i = 1) = \bar{x}(I-p_i^*, p_1, p_2, W_i) + E(\cdot|K_i = 1) \tag{3}$$

The second term relates current consumption to the portfolio choice; it reflects the consumer's stock of energy-using durables.

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*We need consider only the relation between any two fuels to describe the micro-model.

Our concept of micro-level energy demand, represented by Eqs. (1) and (2), separates energy demand into a portfolio decision and a usage decision. Both decisions are interrelated. Equation (1), defined in terms of the attributes of the alternative portfolios of energy-using durables, represents the portfolio decision. It is more of a long-range decision but is also influenced by new information (i.e., attributes of new alternatives) such as might flow from government conservation programs. The portfolio decision, moreover, has the greatest potential for reducing energy consumption since new technologies are adopted here. Usage decisions, represented by Eq. (2), are constrained by the portfolio that is held.* Portfolio decisions, on the other hand, are constrained only by income and technology. The model defined by Eqs. (1) and (2) is called a putty-clay model for its flexibility (i.e., putty) in the portfolio decision which introduces rigidity (i.e., clay) in the usage decision.

Unfortunately, the putty-clay model of Eqs. (1) and (2) cannot be readily estimated with our aggregate national data. We can, however, take Eq. (3), the reduced form version of the putty-clay model, and modify it to accommodate the data. We do this by specifying the aggregate stock adjustment model suggested by Eq. (3).

After summing across fuel types and consumers, we write Eq. (3) as:

$$E = \bar{x}(GNP, P, FED_{-1}) + aS + e \qquad (4)$$

*Conservation programs providing new information may influence usage but only within the parameters set by the portfolio's technology.

Where GNP, gross national product, is the income proxy; P is energy price; FED_{-1} is last year's government expenditure on conservation programs; S is the stock of energy-using durables (a is a parameter); and e is a stochastic residual. S is, however, unobserved. We specify the year-to-year adjustment of durable stocks as dependent on the adjustment of energy demand:

$$\phi(S - S_{-1}) = E - E_{-1} = b(E^* - E_{-1}), \quad 0 < b \leq 1 \tag{5}$$

Also, let the desired level of energy demand, E*, be given by:

$$E^* = x^*(GNP, P, FED_{-1}) + e^*$$

where e* is a stochastic residual. Then we can write aggregate energy demand as:

$$E = bx^*(GNP, P, FED_{-1}) + (1 - b)E_{-1} + be^* \tag{6}$$

with x* a linear function of its arguments. Equation (6) is the basis for the model developed in the next section.

3. MODEL SPECIFICATION

Based on Eq. (6), we developed simple econometric models of U.S. energy use (E) as a function of three independent variables: gross national product (GNP), average energy price (P), and DOE expenditures on energy conservation programs (FED). The models we tested are of the form:

$$E = f(GNP, P, FED)$$

We first discuss the data used in these models and then present the different models tested.

Data*

Data on annual energy consumption are from the Energy Information Administration[1,2] and data on GNP and the GNP deflator (used to correct values of GNP, average energy price, and federal expenditures for inflation) are from the Department of Commerce.[3]

The energy price series should, in principle, reflect the average price of fuels paid by final consumers (i.e., at the point of end-use), averaged across all fuels (coal, petroleum products, natural gas, and electricity). Creating such a price series is difficult because fuels are used both by end-users and by electric utilities. Unfortunately, such a series is not available. The Bureau of Labor Statistics publishes indices on fuel prices paid by households as part of its Consumer Price Index (CPI). The CPI does not include prices paid by users in the commercial transportation, industrial, and commercial sectors. The Producer Price Index, also prepared by the Bureau of Labor Statistics, includes prices paid by nonresidential consumers. However, the two series cannot be easily combined to form a single series on overall U.S. energy prices. The Energy Information Administration publishes a

*The data used to estimate the models (discussed later in this section) are tabulated in Appendix Table A.2.

"composite" price for domestically produced fossil fuels; this series is not relevant because it reflects the prices received by producers (rather than the prices paid by end-users).

The energy price series used in our models was developed by Reister (Fig. 1).[14] He used data on natural gas and electricity end-use expenditures from the Department of Commerce.[3] However, such end-use data are not available for coal and petroleum. Furthermore, coal, petroleum, and natural gas are used as fuels to produce electricity. Thus, total sales of fossil fuels would double count some of the end-use consumption. Reister used data on coal prices from the Energy Information Administration[1,2] and petroleum prices from the Department of Commerce,[3] but did not correct for their use in electricity production.

The price variable is weighted by consumption of each fuel in each sector

$$P_{average} = \sum_i \sum_j (P_{ij}E_{ij})/E_{total}$$

where $P_{average}$ is the average energy price used in our analysis, P_{ij} is the price of fuel i paid by end-use sector j (e.g., in terms of \$/MBtu), E_{ij} is the corresponding consumption (e.g., in terms of MBtu), and E_{total} is total U.S. energy consumption (across all fuels and all end-users). Because of the construction of this definition, changes in the mix of fuels (holding individual fuel prices constant) will lead to changes in the average energy price.* During the 1950s and 1960s, the

*Alternatives to the price series used here are a Laspeyre index (a price index with quantity weights for a particular "base" year) or a Paasche index (with quantity weights for the current year). See ref. 15 for additional discussion of other energy price variables.

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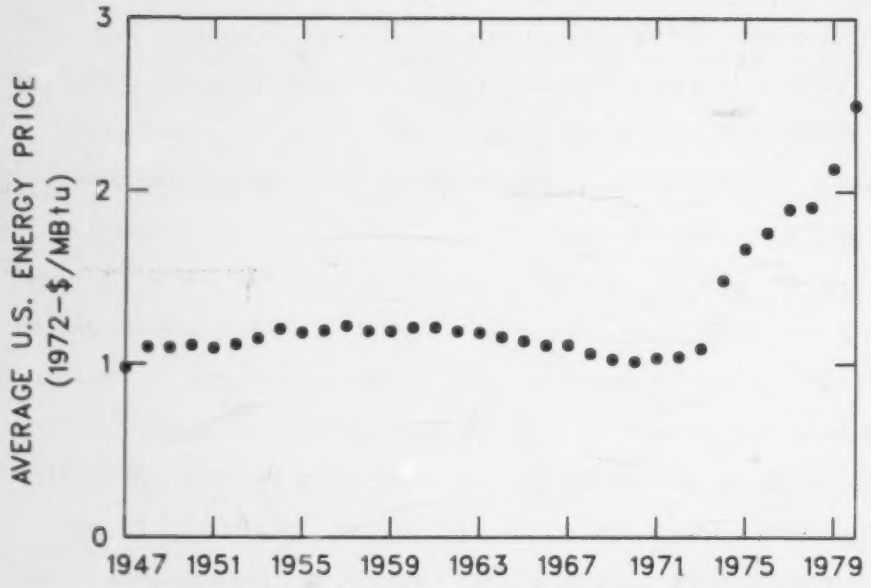

Fig. 1. The average real price of energy to the U.S. economy, 1947-1980.

real prices of individual fuels were generally declining. However, there was a simultaneous shift in the mix of fuels used, with increases in the shares of electricity and gasoline (the two most expensive fuels). These two factors roughly offset each other to yield an average energy price that was almost constant during this period (Fig. 1).

Similar difficulties arise in developing a useful definition of total energy consumption. We used a definition that adds fuel consumption by type of fuel across all end-use sectors, treating electricity in terms of its primary energy equivalent (roughly 11,600 Btu/kWh

for the past several years). Alternative definitions might treat electricity in terms of its end-use energy (3412 Btu/kWh) or might weight fuel consumption by the value of each fuel (i.e., a weighting scheme related to fuel prices).

We obtained budget figures for federal energy conservation programs for fiscal years 1974 through 1980 for DOE and its two predecessor agencies, the Federal Energy Administration (FEA) and the Energy Research and Development Administration (ERDA). We also obtained estimates of the budgets for fiscal years 1970 through 1973 for the National Science Foundation, which funded energy conservation research before FEA and ERDA were created.[16] We assumed that federal expenditures on conservation were zero before 1970. The budget figures include federal expenditures on energy conservation research, regulatory programs, information and outreach programs, and state grant programs. The budget figures used in the present analysis are aggregated across program types (e.g., R&D vs outreach) even though the dynamics of energy-use response are quite different among the types of government programs considered.

These budget figures (Fig. 2) do not include all federal expenditures on energy conservation. Many federal agencies (e.g., the Departments of Transportation, Commerce, and Agriculture) have energy conservation programs related to their particular areas of interest. Tax expenditures are also an important form of federal conservation activity. For example, 6.0 million households claimed $592 million in residential energy tax credits in 1978, as part of their federal income tax returns.[17] Finally, the DOE budget figures do not include additional expenditures

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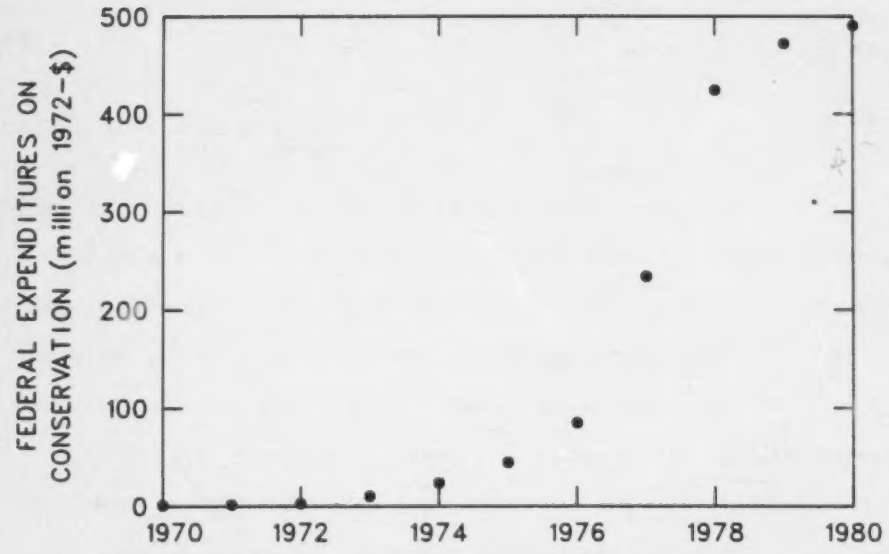

Fig. 2. Energy conservation expenditures of the U.S. Department of Energy and its predecessor agencies, 1970-1980. (Such expenditures are assumed to be negligible for earlier years.)

on conservation programs from other institutions such as state and local governments[18] and private and public electric and gas utilities.[19,*]

We think that these excluded institutional conservation expenditures increased roughly in parallel with the DOE expenditures included in our analysis (i.e., there is considerable multicollinearity between total

*The Tennessee Valley Authority provided home energy audits to about 20% (more than 490 thousand) of their residential customers between August 1977 and September 1981 (ref. 20). The California electric and gas utilities spent $91 million in 1980 and $157 million in 1981 on their customer conservation programs (ref. 21).

government/utility conservation expenditures and the DOE expenditures included). If this is true, then the DOE budget figures included in our equations are good proxies for the larger government/utility expenditures.

Models

We estimated and examined four different specifications of the model suggested by Eq. (6) using the data discussed above. All are dynamic models to conform with the specification of Eq. (6).* Two of the models use national annual energy use (E) as the dependent variable, one uses the ratio of energy use to GNP (E/GNP), and the last uses the difference between this year's and last year's energy uses ($E - E_{-1}$).

We had initially planned to estimate these models using annual data from 1947 through 1973 and then use the models to develop alternative projections for the 1974 to 1980 period. Unfortunately, there was virtually no change in either the average energy price or federal expenditure variable between 1947 and 1973 (Figs. 1 and 2); models developed with only this data generally had coefficients that were statistically insignificant. Therefore, the models presented here include the full data series from 1947 through 1980.†

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*In preliminary model explorations, both static and dynamic formulations were estimated. A static model might be of the form: $E = a + bGNP + cP + dFED$; the comparable dynamic formulation would be $E = a + bGNP + cP + dFED + eE_{-1}$, where -1 refers to the preceding year. The dynamic specifications consistently outperformed their static counterparts on both theoretical and statistical grounds.

†This complicates interpretation of model "predictions," because the prediction period is not independent of the model estimation period.

We encountered two additional problems with the models tested. First, the independent variables were often correlated with each other (multicollinearity); in particular energy prices and federal conservation expenditures both increased sharply during the 1970s (compare Figs. 1 and 2). This makes it difficult to separate the effects of the two variables from each other.*

Second, regression analyses of time series data often show patterns in the residuals (the unexplained portion of the variation). Such patterns imply that the error of prediction for one year is correlated with the error for earlier years.

We tested different ways of including federal expenditures in the equations to resolve these difficulties. Some models included last year's expenditure (FED_{-1}) as the appropriate independent variable because DOE's budget is never fully spent in the year it is appropriated; it takes time for the money to get out into the field. We also tested the product of last year's expenditure and this year energy price ($FED_{-1} \cdot P$) to test the interaction (and complementarity) between government conservation programs and rising energy prices. Finally, we tested the ratio of last year's federal expenditure to this year's price (FED_{-1}/P) to test for possible negative interactions between government programs and rising prices.

The equations with either FED or FED_{-1} as the independent variable had problems with multicollinearity and serial correlation.[22] The

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*In none of the four specifications was multicollinearity a serious problem. Although the partial correlations among variables were sometimes high, the resulting inflation of standard errors did not dilute their influence; nearly all the coefficients were significant at the 1% level or better.

equations with FED_{-1}/P as the independent variable also gave poor results (serial correlation, multicollinearity). Only the equations with $FED_{-1}P$ as the independent variable yielded meaningful statistics.

We tested three methods to reduce multicollinearity. First, we developed a difference model in which all the variables are first differences (e.g., $E - E_{-1}$). Second, we used the principal components method[23] to create a new pair of variables (both linear combinations of FED_{-1} and P) that are linearly independent of (orthogonal to) each other; this approach eliminates the multicollinearity between energy price and federal expenditures.* Finally, we created an instrumental variable for FED as a function of GNP and P and then used the instrumental variable (predicted values) instead of the actual values of FED in the equations for energy use. Unfortunately, the instrumental variable was still highly correlated with average energy price.

We initially tested models that included a time variable (year - 1947) as an explanatory variable (see Appendix B of ref. 12). The time variable was intended to capture possible improvements in energy efficiency due to technological progress that were independent of changes in GNP, fuel prices, and government programs. This variable was not included in the final equations because its coefficient was almost always insignificant.

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*Only the first principal component had a coefficient that was statistically significant. Hence the second component was not included in the final equations. The eigenvalues for the principal components are 1.88 and 0.12 for the first and second components, respectively.

Ultimately, we obtained four models that yielded useful results:

$$E = a + bGNP + cP + dFED_{-1}P + eE_{-1} \quad (1)$$

$$E = a + bGNP + cPRIN + dE_{-1} \quad (2)$$

$$E/GNP = a + bPRIN + c(E/GNP)_{-1} \quad (3)$$

$$DE = a + bDGNP + cDP + dDFED \quad (4)$$

where E is annual U.S. energy use (in Quads), GNP is annual gross national product (in billion 1972-$), P is average energy price (in 1972-$/MBtu), FED is annual (calendar year) energy conservation budgets (in million 1972-$), PRIN is the first principal component (= -2.81 + 1.98P + 0.00620FED$_{-1}$); -1 refers to the preceding year, D refers to the first difference (e.g., DE = E - E$_{-1}$), and a,b,c,d,e are coefficients estimated by the regression model.

The four equations were estimated using ordinary least squares with the Statistical Analysis System (SAS).[24] These models all have very high explanatory power (R^2), which is not unusual for models estimated with time-series data (Table 2).* The first two models explain more than 99% of the variation in annual energy use, the third model explains more than 90% of the variation in E/GNP, and the fourth model explains almost 80% of the variation in changes in annual energy use.

We tested for serial correlation using the Durbin-Watson D statistic, first-order autocorrelation, and the runs test (Table 3). The D statistic

*The complete regression results for these four models are in Appendix Tables A.3-A.6.

Table 2. Regression results for models of annual U.S. energy use[a,b]

Model number	Dependent variable	Independent variable coefficients: Constant	GNP	Energy price	Federal expend.	Princ. comp.[c]	Lagged dependent variable	R^2
1	E	5.527	0.0331	-3.640	-0.00243[d]	e	0.433	0.997
2	E	0.736	0.0338	e	e	-1.360	0.417	0.997
3	E/GNP	0.0162	e	e	e	-0.000636	0.719	0.913
4[f]	DE	0.0461	0.0535	-5.514	-0.00802	e	e	0.779

[a]Units for the variables are: Quads for E, billion 1972-$ for GNP, 1972-$/MBtu for energy price, and million 1972-$ for federal expenditures. All the equations have 33 observations (1948 through 1980).

[b]All the coefficients are significant at the 1% level or better except: the constant term in equations 2 and 4 is not significant at any reasonable level and the federal expenditures coefficient in equations 1 and 4 is significant at the 8% level.

[c]The principal component (equations 2 and 3) is defined as $-2.81 + 1.98P + 0.00620FED_{-1}$; it is the first principal component based on P and FED_{-1}.

[d]The federal expenditure variable in equation 1 is $FED_{-1}P$.

[e]The variable was not included in the equation.

[f]All the variables in equation 4 are first differences.

Table 3. Regression diagnostics for models of annual U.S. energy use

Model number	Runs test[a]	First-order autocorrelation	PRESS statistic
1	0.04	0.16	37.7
2	0.01	0.17	36.3
3	0.44	0.05	0.000035
4	0.39	0.12	27.3

[a]These numbers are the probability of having fewer runs in the residuals than observed given the number of positive and negative residuals that occurred (ref. 26).

is appropriate only for equations that do not include a lagged dependent variable. For equations with a lagged dependent variable, the Durbin-K statistic[25] is the appropriate test for serial correlation; unfortunately the SAS procedures[24] do not include this statistic.

The Durbin-Watson D statistics[22] for the first two models are slightly lower than the upper bound (d_u) at the 5% level: 1.61 compared

with 1.81 for model 1, and 1.58 compared with 1.73 for model 2. The D statistics for models 3 and 4 are higher than the d_u statistic. These results suggest a possible problem with serial correlation in models 1 and 2 and no such problem in models 3 and 4. (The D statistic is appropriate, however, only for model 4.)

The runs test[26] showed that models 3 and 4 have no problem with serial correlation. On the other hand, the results for model 1 and (especially) model 2 suggest a problem with systematic error.* First-order autocorrelation is low and apparently not a problem with any of the four models (Table 3). Taken together, the D statistics, runs test, and first-order autocorrelation suggest possible problems with models 1 and 2 and none with models 3 and 4.

The prediction sum of squares (PRESS†) statistic[27] is useful in comparing alternative specifications of similar models using the same dependent variable. As such, it can be used only to compare models 1 and 2; the results (Table 3) show that the two models are equally good.

We ran all four models using the forward selection technique in the SAS STEPWISE procedure.[24] The C_p statistic decreased monotonically with inclusion of each additional explanatory variable for all four models.[28] This suggests that the addition of each subsequent variable does not substantially increase the variance of the fitted model; the increase in variance is less than the decrease in bias so that each

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*The runs test numbers in Table 3 show the probability of having as few runs as was observed.

†PRESS is defined as $\sum_{i=1}^{n} (Y - \hat{Y}_i)^2$ where $\hat{Y}_i$ is the estimator of $E(Y_i)$ excluding the i-th observation, and Y and Y_i are both vectors (ref. 27).

variable improves the overall performance of the model. It was interesting to note, however, that the federal expenditure variable was always the last one to enter the equation. This suggests that, although it is a significant determinant of national energy use, it is not as important as GNP and energy price.

Multicollinearity among independent variables might be a problem in models 1 and 2. The correlation (R^2) between energy price and $FED_{-1}P$ (model 1) was 0.75. Models 1 and 2 also showed high correlation ($R^2 = 0.98$) between the lagged dependent variable (E_{-1}) and GNP. The independent variables in models 3 and 4 had low correlation among explanatory variables.

Almost all the coefficients in all four models are statistically significant at the 1% level or better. Only the constant term in models 2 and 4 is insignificant, and the federal expenditure term in models 1 and 4 is significant at the 8% level. Thus, these equations not only explain almost all the variation in their dependent variable but the explanatory variables are all important determinants of energy use.

The coefficients of GNP are positive in all equations, which conforms to our expectation that increasing economic activity leads to an increase in national energy use. The long-run elasticity of energy use with respect to GNP (Table 4) is close to 1.0; this suggests that, all else being equal, energy use and GNP increase proportionately.*

*A long-run elasticity of energy use with respect to GNP of one does not mean that national energy use increases in lock-step with increases in GNP. The relationship between energy use and GNP is affected by changes in fuel prices and government programs as well.

Table 4. Elasticities of U.S. energy use[a]

Model number	Elasticity with respect to: GNP	Energy price	Time period
1	0.57	-0.09	short-run
	1.01	-0.16	long-run
2	0.58	-0.06	short-run
	0.99	-0.11	long-run
3	[b]	-0.02	short-run
	[b]	-0.10	long-run
4[c]	0.91	-0.13	short-and long-run

[a]These elasticities are computed using the coefficients from Table 2 and the mean values (1948-1980) of the dependent and independent variables.

[b]This equation uses E/GNP as the dependent variable, which implicitly assumes a long-run elasticity of 1.0 for energy use with respect to GNP.

[c]This equation uses first differences; the long- and short-run elasticities are therefore identical.

The coefficients of average energy price are negative in all equations, which again conforms to our expectation that increasing fuel prices leads to reduced energy consumption. The long-run elasticity of energy use with respect to average energy price is -0.10 to -0.16, depending on the model. These fuel price elasticities are lower than those obtained by other modelers. The Energy Modeling Forum, for example, reviewed several econometric and end-use models of energy demand.[29] Although there was a wide range in overall elasticity estimates, the average was about -0.5, roughly triple the value estimated with the models developed here.* The price elasticity estimated with

*On the other hand, Parikh and Rothkopf estimated the long-run elasticity of U.S. energy demand in 1970 as -0.19 (ref. 30), close to our values.

the present models might differ from those obtained with other models because of our particular definitions for "average" energy price and total energy use, and because of our explicit inclusion of federal energy conservation expenditures.*

The coefficients of federal conservation expenditures are negative in all equations; this too conforms to our expectation that increased government activity in energy conservation reduces energy use. We do not present elasticitics of energy use with respect to this expenditure variable because such elasticities would surely overstate the effectiveness of DOE expenditures. Recall that our expenditure variable includes only the budget of the federal "energy" agency (e.g., DOE, FEA, ERDA) and excludes related expenditures by other federal agencies, state and local agencies, gas and electric utilities, and federal and state tax expenditures. For example, 15 states had state tax credits and/or deductions for residential conservation and/or renewables investments in 1978; two states added such tax incentives in 1979.[18]

The results obtained with the federal expenditure variable suggest that there is a positive interaction between increasing energy prices and increasing federal conservation budgets — increasing energy prices makes federal programs more effective at reducing energy use and increasing federal conservation budgets increases the sensitivity of energy use to energy prices.†

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*Our definition of elasticity is equivalent to the partial derivative of energy use with respect to energy price (i.e., government conservation expenditures are held constant). Other estimates are more akin to the total derivative (which implicitly includes the effects of government programs on energy use).

†These results can be seen mathematically with, for example, model 1. The elasticity of energy use with respect to energy price is $-(3.64 + 0.00243FED_{-1})(\overline{P/E})$ and the elasticity with respect to federal expenditures is $-0.00243P(\overline{FED_{-1}P/E})$ where $(\bar{\ })$ is the mean value (averaged across all years).

This finding is reasonable. To a large extent, government (and utility) conservation programs are designed to provide energy users with additional and improved information on their energy-related choices (both capital purchases and operations). Thus, conservation programs promote and accelerate actions that are in the economic self-interest of businesses and households. These programs operate through the market mechanism; thus the effects of conservation programs and higher prices are complementary.*

The coefficients of the lagged dependent variables in models 1 and 2 suggest that almost 60% of the long-run response to energy price, GNP, and conservation program changes occurs in one year. The comparable coefficient in model 3 suggests that less than 30% of the long-run response occurs in the first year. Model 4 (the difference equation) is a static model that implicitly assumes all changes occur in one year (i.e., that the short- and long-run responses are the same).

The statistical tests discussed earlier and the model coefficients themselves (signs, magnitudes, statistical significance, and interpretation) suggest that these four models do an acceptable job of explaining variations in national energy use between 1947 and 1980. However, the question arises as to whether these are the only models capable of providing such explanations.

*This finding of positive interaction is supported by the poor results obtained with models that included the ratio of federal expenditures to energy price (FED_{-1}/P) as an explanatory variable.

To explore the possibility of acceptable alternative hypotheses concerning national energy use, we tested several variations of model 1.* These models were compared to each other using an F-test.[31,†]

We began by adding national resident population and national heating degree days (HDD) as explanatory variables to the original equation (which included GNP, energy price, product of last year's federal expenditures and this year's energy price, and last year's energy use as explanatory variables; see Table 2). Models with these two additional variables or population alone were, according to the F-test, superior to the original model. In addition, the coefficients for both population and heating degree days were significant at the 5% level. However, the model with the addition of HDD alone was not superior to the original model and the HDD coefficient was significant at only the 14% level.

We next tested several alternative specifications including a shift variable (D) equal to zero from 1947 through 1973 and equal to one from 1974 through 1980, a time trend (t) equal to zero until 1973 and then equal to (year - 1973) from 1974 to 1980, and interaction terms between one or both of these new variables and the original energy price and federal expenditure variables.

The purpose of these additional terms is to test the alternative hypothesis that structural changes in the U.S. economy occurred after

*Our choice of model 1 was based primarily on convenience.

†The computed F statistic is $[(SSE_2 - SSE_1)/(m-k)]/[SSE_1/(n-m)]$ where SSE refers to the error sum of squares for the model, n is the number of observations, m is the number of parameters in model 1, and k is the number of parameters in model 2 ($k < m$).

1973 and that these changes explain recent patterns of energy use. Comparisons among these models (eight different specifications) showed the following:

1. Adding the shift variable (D) alone to the basic equation did not improve model performance: $F_{7,25} = 0.03$.
2. Adding interactions between the shift variable and energy price, $(1 + P + Pt)D$, significantly improved model performance: $F_{7,23} = 2.45$.
3. Adding interactions between federal expenditures and the shift variable, $[1 + FED_{-1}P(1 + t)]D$, significantly improved model performance: $F_{7,23} = 2.26$.

These tests suggest that our original model 1 is not the only one capable of explaining variations in national energy use. For example, a model that does not include any variables with federal expenditures and does include additional energy price terms interacted with the shift variable and time trend performs well.

Although several of these (alternative) models provide good explanations of national energy use trends, the results presented in the following section are based solely on the models discussed earlier in this section (Tables 2-4). We do not include these expanded models for several reasons. First, all else equal, we prefer a parsimonious model (with as few explanatory variables as possible); this is particularly important here because there are only 33 observations in our data set.

Second, many of the variables added were not statistically significant and (in some cases) addition of new variables caused the original

variables to be insignificant. This is probably a consequence of the high degree of multicollinearity among these variables (our third reason). For example, the correlation (R^2) between population and GNP is 0.95, between population and energy price is 0.35, and between population and heating degree days is 0.21. Similarly, the correlation between the shift variable and energy price is 0.81, between the shift variable and GNP is 0.55, between the shift variable and population is 0.42, and between the shift variable and the federal expenditure variable is 0.41.

4. RESULTS

The four models discussed in Sect. 3 were used to project energy use from 1973 to 1980 under four different sets of assumptions:

1. GNP, energy prices, and federal expenditures follow their actual paths.
2. GNP and energy prices follow their actual paths, federal expenditures remain constant at their 1972 level ($2.9 million in 1972-$).
3. GNP follows its actual path, federal expenditures remain constant at their 1972 level, and energy prices remain constant at their 1973 level ($1.09/MBtu in 1972-$).
4. GNP grows at its pre-embargo rate (4.2%/year real), federal expenditures and fuel prices remain constant.

The four projections and values of actual energy use are shown in Figs. 3-7 for each of the models; Table 5 shows simple averages across all four models. U.S. energy use in 1980 was almost 22 Quads below what a pre-embargo business-as-usual projection (#4 above) would suggest.

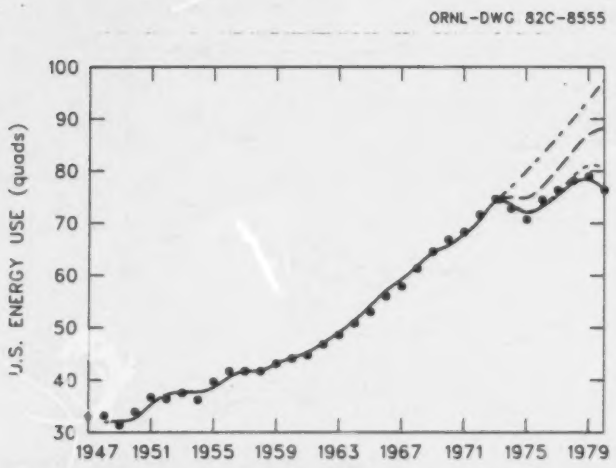

Fig. 3. U.S. energy use, 1947-1980, and projections with model 1. The top projection assumes that GNP grows at its pre-embargo rate (4.2%/year) and that real fuel prices and federal conservation expenditures remain constant at their 1973 and 1972 values, respectively. The second projection assumes that GNP follows its actual path and that fuel prices and federal expenditures remain constant. The third projection assumes that GNP and fuel prices follow their actual paths and that federal expenditures remain constant. The bottom projection assumes that GNP, fuel prices, and federal expenditures all follow their actual paths during the 1973-1980 period. The dots are actual energy use.

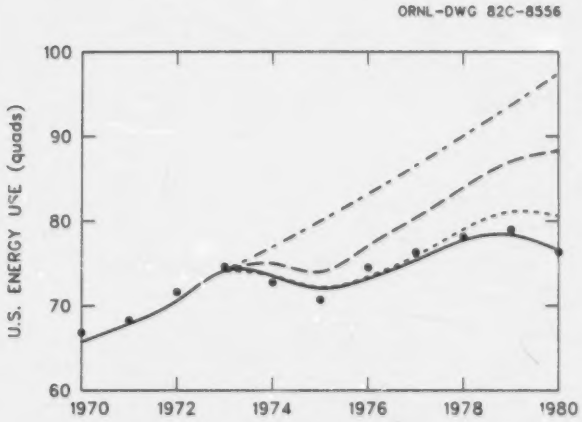

Fig. 4. U.S. energy use, 1970-1980, and projections with model 1.

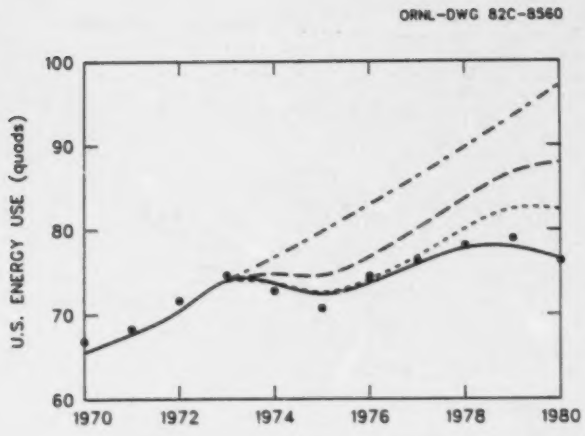

Fig. 5. U.S. energy use, 1970-1980, and projections with model 2.

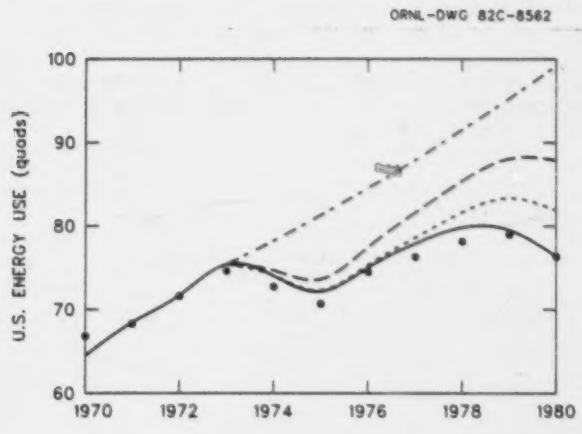

Fig. 6. U.S. energy use, 1970-1980, and projections with model 3.

ORNL-DWG 82C-8558

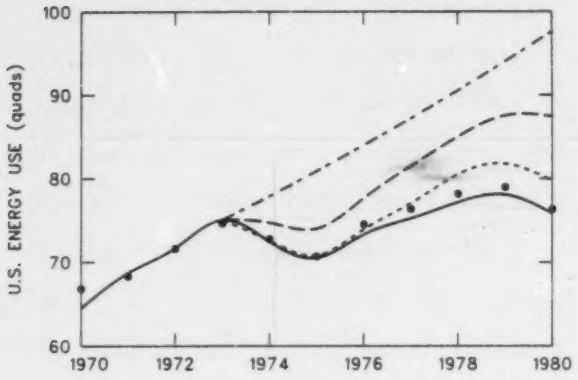

Fig. 7. U.S. energy use, 1970-1980, and projections with model 4.

Table 5. Model results on U.S. energy use relative to historical trends[a]

	Actual energy use	Effect on energy use (Quads) of:				
		GNP	Fuel prices	Federal expenditures	Other	Total
1974	72.8	2.7	1.4	0.0	0.7	4.7
1975	70.7	6.2	2.3	0.1	1.1	9.8
1976	74.5	6.4	3.0	0.3	-0.7	9.1
1977	76.3	6.1	3.9	1.0	-0.2	10.6
1978	78.2	6.0	4.2	2.2	0.0	12.3
1979	79.0	6.7	5.2	3.7	-0.4	15.1
1980	76.3	10.0	6.8	4.8	0.0	21.5

[a]These results are obtained by averaging the projections from the four individual models.

Almost half (10 Quads) of the reduction (the difference between runs 3 and 4, the top two projections in Figs. 3-7) was due to slower economic growth.

The remaining 12 Quads represents increases in overall energy efficiency. Of this 12 Quad reduction, almost 7 Quads was due to higher fuel prices (the difference between runs 2 and 3, the middle two projections in Figs. 3-7), and almost 5 Quads was due to government conservation programs (the difference between runs 1 and 2, the bottom two projections in Figs. 3-7).

The projections for the entire post-embargo period show an increasing divergence between actual energy use and the business-as-usual projection. The difference increases monotonically from less than 5 Quads in 1974 to almost 22 Quads in 1980. Changes in GNP consistently account for almost half the reduction in energy use; the GNP effect increases from almost 3 Quads in 1974 to 10 Quads in 1980. In a similar fashion, the effect of fuel price increases is consistently about one third of the total difference, growing from just over 1 Quad in 1974 to almost 7 Quads in 1980.

The estimated effect of government conservation programs starts out very small (only 0.1 Quad in 1975, about 1% of the total reduction that year) and then grows very rapidly at the end of the projection period, reaching almost 5 Quads in 1980. During this period, DOE's energy conservation budget also grew rapidly: by 91% between 1975 and 1976, 172% between 1976 and 1977, 81% between 1977 and 1978, 11% between 1978 and 1979, and 4% between 1979 and 1980 (Fig. 2). The overall increase in the DOE conservation budget was almost 1000% between 1975 and 1980.

Given these large budget increases, it is not surprising to see a rapidly increasing energy-saving effect.

The unexplained residual (difference between the bottom projection and actual energy use) is quite small in all years, averaging less than 0.1 Quad. In our earlier analysis of national energy use, in which we did not include federal conservation expenditures as an explanatory variable, the unexplained residual was much higher.[12] In that analysis, the residual was 1 Quad in 1978, 2 Quads in 1979, and 2 Quads in 1980. The sharp reduction in this residual when a variable is included to capture federal conservation budgets lends support to the notion that government conservation programs have reduced national energy use.

There is considerable consistency in the results among the four models. The difference between the historical trends projection and actual energy use in 1980 among the four models ranges from 20.9 to 21.8 Quads, with a mean of 21.5 Quads. The estimated effect of GNP changes on 1980 energy use ranges from 9.2 to 11.3 Quads, with a mean of 10.0 Quads. The estimated effect of energy price changes on 1980 energy use ranges from 5.6 to 7.8 Quads, with a mean of 6.8 Quads. The estimated effect of federal conservation expenditures ranges from 3.9 to 5.8 Quads, with a mean of 4.8 Quads. The unexplained residual ranges from -0.5 to 0.2 Quads, with a mean of zero. This consistency among models with different specifications is encouraging. It suggests that the results concerning the influence of GNP, energy prices, and federal conservation expenditures on energy use are robust with respect to model formulation.

In addition to checking for consistency among projections made with different models, we also compared the four projections made with each model to see if the intramodel differences were statistically significant. A t-test of the differences* (e.g., between a model's projection of 1980 energy use with constant federal expenditures and the same model's projection of 1980 energy use with increasing federal expenditures) showed that almost all the 1980 differences (three differences for each model times four models) were significant at the 1% level or better. Only two differences — between the two lowest projections for models 1 and 4 (Figs. 4 and 7) — were not, and these were significant at the 5% level. These results provide further evidence that the effects of GNP, fuel prices, and federal expenditures on energy use are real and not just artifacts of a particular statistical model.

The Energy Information Administration[32] recently analyzed the 3.7% decline in energy use between 1979 and 1980 using its energy end-use models (Table 6). EIA's results show that approximately 40% of this one-year decline was due to operational changes (e.g., thermostat settings in residential and commercial buildings, reduced transportation vehicle mileage) motivated by energy price increases that year.

About 20% of the decline in energy use was due to technical energy-efficiency improvements (e.g., additional attic insulation in homes, automatic control systems in commercial buildings, new cars with higher

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*The t statistic used is $t = (y_i - y_j)/\theta_{ij}$, where y is one of the four projections of 1980 energy use made with a particular model and θ_{ij} is the standard error of the difference between the i and j projections and is equal to $mse[V_i(X'X)^{-1}V_i^1 + V_j(X'X)^{-1}V_j^1 - 2V_j(X'X)^{-1}V_i^1]$; mse is the mean square error of the regression.

Table 6. EIA analysis of energy use decline between 1979 and 1980[a]

Short-run price response		
Operations	41%	
Technology	14%	20% Technology
Long-run price response	6%	
GNP	8%	
Other	31%	
Total	100%	

[a]1980 energy use (76.3 Quads) was 3.7% below the 1979 level.

Source: ref. 32.

fuel economy). Part of the increase in technical efficiency was due to price increases in 1980; part was due to price increases in earlier years. This lag is reasonable given the long lifetimes of the nation's capital stock (homes, commercial buildings, transportation vehicles, factories).

Roughly 8% of the energy-use decline was due to the slight decline in GNP between 1979 and 1980. Finally, nearly one-third of the decline in energy use is a residual, unexplained by the EIA models. This residual includes errors in the models and data, structural changes in the economy, and the effect of government and utility conservation programs.

Our models yield results that are similar to those obtained with the EIA models. Comparison of our 1979 and 1980 model results shows that 0.1 Quads of the reduction in energy use between 1979 and 1980* was due to lower GNP (compred to EIA's 0.2 Quads), 1.2 Quads was due to

*These numbers cannot be compared to those in Table 5. The present energy-saving estimates reflect changes between 1979 and 1980; the estimates in Table 5 reflect differences between 1980 and a "historical trends" projection for 1980.

fuel price increases (compared to EIA's 1.4 Quads), 0.4 Quads was due to increases in government programs (EIA has no comparable number), 0.1 Quads was due to changes in earlier years (compared to EIA's 0.2 Quads), and 0.8 Quads was unexplained (equal to EIA's 0.8 Quads residual).

5. ADDITIONAL RESEARCH

The present analysis represents an important step forward in analysis of recent trends in national energy use and of the role of government programs in affecting these trends. Nevertheless, considerable work remains to be done to further explore these issues. Perhaps the greatest weakness in the present work is the high level of aggregation. Additional work in this area should begin by disaggregating the analysis in three different ways.

First, the analysis should be done separately for each of the major energy-consuming sectors of the economy: residential buildings, commercial buildings, transportation (both passenger and freight), and industry (manufacturing, mining, agriculture). The patterns of energy use and the responsiveness of these patterns to changes in government programs, energy prices, and economic activity differ substantially across sectors. For example, federal programs have focused more heavily on the residential sector than on other sectors. Also the composition of GNP has been changing during the past few decades, shifting from production of goods (industry) to production of services (commercial sector); use of the aggregate GNP measure obscures these shifts among sectors and the consequent energy use patterns.

Second, the analysis should be disaggregated by fuel type. It is more important, from a public policy standpoint, to reduce consumption of petroleum than to reduce consumption of coal. The present analysis, which aggregates across all fuel types, cannot account for changing trends with respect to fuel mix in each sector. Also, disaggregation by fuel type will resolve the problems discussed earlier with the present definition of an average energy price.

Finally, the analysis should be disaggregated with respect to type of government conservation program. Some programs mandate changes in technical energy efficiency (e.g., appliance efficiency standards) or in energy consumption (e.g., the 55 mph speed limit). Although these programs have small costs to the federal government, they may impose substantial costs on society at large. Information programs expand the set of known feasible options to both households and producers. Financial incentives (e.g., tax credits) reduce the cost to consumers of investments in energy-efficient technologies. Finally, R&D programs improve performance characteristics of systems that will be available in the future. Clearly these different types of programs have different costs, different effects on consumers, and different effects over time.

In addition to disaggregation of DOE budgets by type of program, it would be desirable to collect and include data on non-DOE government and utility conservation programs. Such figures should include federal tax credits (Treasury Department), low-income energy assistance programs (Department of Health and Human Services), as well as the conservation programs of other federal agencies. In addition, programs funded by state and local agencies and by electric and gas utilities should be included.

Even within the present aggregate analysis, additional work might be worthwhile. As discussed earlier, we tested population and heating degree days as possible explanatory variables. Other variables that might be tested include the world price of oil (as a proxy for the marginal cost of energy) the year-to-year change in energy price, and variables related to recent energy shortages (1973/74 and 1979).

6. CONCLUSIONS

This report discusses trends in U.S. energy use for the 1973-1980 period. This post-embargo period is examined in terms of how energy use changed relative to pre-embargo trends and the major determinants of these changes.

Simple models that explain changes in U.S. annual energy use were developed using gross national product, average energy price, and federal expenditures on conservation programs as explanatory variables. These models were than used to develop alternative projections of energy use from 1973 through 1980.

These projections suggest that U.S. energy use in 1980 (76 Quads) was almost 22 Quads lower than it would have been had pre-embargo trends in economic growth, fuel prices, and government conservation programs continued unchanged. Of this total reduction, almost half (10 Quads) was due to slower economic growth between 1973 and 1980.

The remaining reduction in 1980 energy use (almost 12 Quads) was due to increased energy efficiency. Nearly 7 Quads of this efficiency

improvement was stimulated by increasing energy prices; nearly 5 Quads was stimulated by government conservation programs.

Before ending this report, it is worthwhile to mention some of the caveats associated with the present analysis and its findings. First, the quality of data related to historical energy consumption is poor. In particular, we relied on estimates of average energy price that we know are not well defined (see discussion in Sect. 3). Similarly, the data on "institutional" conservation expenditures includes only a portion of such funds — that spent by the U.S. Department of Energy and its predecessor energy agencies. Conservation expenditures by other federal agencies, by state and local agencies, and by public and private utilities are not included in our data. We also do not include state and federal tax expenditures (income tax credits and deductions, property tax exemptions, etc.). We assume that these omitted expenditures are closely correlated with the DOE expenditures that are included in our analysis.

Second, the econometric models used to develop estimates of energy use are imperfect. These (and other energy demand models[33]) suffer from problems related to the dynamics of change, aggregation, identification (interdependencies among independent variables), interactions of energy supply and demand, equation form, and estimation technique.

Third, we examine changes in energy use relative to a business-as-usual baseline. The baseline projection used here is intended to reflect energy consumption levels that would have occurred between 1973 and 1980 had pre-embargo trends continued unchanged. However, there is considerable ambiguity in defining these trends (in terms of the key independent

variables and the appropriate time period to use in developing trajectories of these variables).

Finally, our models include only a few independent variables. Other factors that might have influenced national energy use that are not included in the model may be correlated with the variables we did use. For example, increasing consumer awareness of their energy conservation options may have been collinear with, but somewhat independent of, increasing government conservation expenditures. If this is the case (and it would be very difficult to analyze) then the estimated energy-saving effects of government programs are overestimated in our models.

Despite the limitations in this analysis, we think that our results contribute to an improved understanding of the determinants of national energy use. This is primarily because of the explicit inclusion of federal energy conservation budgets in the models of energy use.

Three major conclusions emerge from this analysis. First, energy use trends during the past few years were substantially different from those of the preceding two decades. In particular, energy use grew much more slowly after 1973 than it had before then.

Second, more than half the slower growth in energy use was due to improvements in energy efficiency; the remainder was due to slower economic growth.

Third, government energy conservation programs played an increasingly important role in improving energy efficiency, accounting for more than 40% of the efficiency improvements in 1979 and 1980.

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Appendix Tables

Table A.1. Conversion factors from British to SI units[a]

To convert from	To	Multiply by
Btu	J	1055
ft^2	m^2	0.0929
kBtu/ft^2	GJ/m^2	0.01136
$/MBtu	$/GJ	0.948
¢/kWh	$/GJ	2.778
kWh	J	3,600,000
Btu/kWh	J/J	0.000293
°F	°C	$T_{°C} = (T_{°F} - 32)/1.8$
degree days (65°F base)	degree days (18.3°C base)	0.5556

[a]Prefixes are used in the SI system to form decimal multiples of the base units (factors of 10^3): k = 10^3, M = 10^6, G = 10^9, T = 10^{12}, P = 10^{15}, and E = 10^{18}.

Source: American Society for Testing and Materials, *Standard for Metric Practice*, E 380-76, February 1976.

Table A.2. Data used in estimation of regression equations[a]

YEAR	E	GNP	P	FED	DEFLATOR
1947	32.962	468.3	0.97759	0.000	49.70
1948	33.217	487.7	1.09677	0.000	53.13
1949	31.413	490.7	1.09273	0.000	52.59
1950	33.923	533.5	1.10962	0.000	53.64
1951	36.712	576.5	1.09237	0.000	57.27
1952	36.397	598.5	1.11424	0.000	58.00
1953	37.529	621.8	1.14803	0.000	58.88
1954	36.208	613.7	1.20254	0.000	59.69
1955	39.666	654.8	1.18032	0.000	60.98
1956	41.662	668.8	1.19162	0.000	62.90
1957	41.675	680.9	1.21810	0.000	65.02
1958	41.650	679.5	1.18794	0.000	66.06
1959	43.100	720.4	1.18762	0.000	67.52
1960	44.080	737.1	1.20919	0.000	68.67
1961	44.730	756.6	1.20956	0.000	69.28
1962	46.800	800.3	1.18677	0.000	70.55
1963	48.610	832.5	1.17983	0.000	71.59
1964	50.780	876.4	1.15511	0.000	72.71
1965	52.990	929.3	1.13132	0.000	74.32
1966	55.990	984.8	1.10638	0.000	76.76
1967	57.890	1011.4	1.10813	0.000	79.02
1968	61.320	1058.1	1.05929	0.000	82.57
1969	64.530	1087.6	1.02615	0.000	86.72
1970	66.830	1085.6	1.01273	0.657	91.36
1971	68.300	1122.4	1.03314	1.510	96.02
1972	71.630	1185.9	1.04042	2.850	100.00
1973	74.609	1255.0	1.08789	10.360	105.69
1974	72.759	1248.0	1.48137	23.669	114.92
1975	70.707	1233.9	1.66532	44.720	125.56
1976	74.510	1300.4	1.75887	85.847	132.13
1977	76.332	1371.7	1.89475	233.855	139.83
1978	78.150	1436.9	1.90880	424.325	150.05
1979	78.968	1483.0	2.13141	472.139	162.77
1980	76.345	1480.7	2.49607	490.302	177.36

[a]E is annual U.S. Energy use in Quads (10^{15} Btu), GNP is annual gross national product in billion 1972-$, P is average energy price in 1972-$/MBtu, FED is annual DOE (and predecessor agencies) expenditures on conservation programs in million 1972-$, and DEFLATOR is the GNP deflator (1972 = 100).

Table A.3. Regression results for model 1

DEPENDENT VARIABLE: BTU

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
MODEL	4	8116.61408027	2029.15352007
ERROR	28	25.29675724	0.90345562
CORRECTED TOTAL	32	8141.91083752	

MODEL F =	2245.99	PR > F =	0.0001

R-SQUARE	C.V.	STD DEV	BTU MEAN
0.996893	1.7523	0.95050282	54.24278788

SOURCE	DF	TYPE I SS	F VALUE	PR > F
PRICE	1	2784.09081209	3081.60	0.0001
GNP_B_72	1	5297.72333506	5863.84	0.0001
FEDXP_P	1	9.52542351	10.54	0.0030
BTU_P	1	25.27450961	27.98	0.0001

SOURCE	DF	TYPE IV SS	F VALUE	PR > F
PRICE	1	11.03148222	12.21	0.0016
GNP_B_72	1	51.48792366	56.99	0.0001
FEDXP_P	1	2.98541377	3.30	0.0798
BTU_P	1	25.27450961	27.98	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	5.52723822	4.58	0.0001	1.20685670
PRICE	-3.63968946	-3.49	0.0016	1.04159961
GNP_B_72	0.03313837	7.55	0.0001	0.00438967
FEDXP_P	-0.00242620	-1.82	0.0798	0.00133468
BTU_P	0.43268028	5.29	0.0001	0.08180487

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	25.29675724
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
FIRST ORDER AUTOCORRELATION	0.15819467
DURBIN-WATSON D	1.61216328

Table A.4. Regression results for model 2

DEPENDENT VARIABLE: BTU

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
MODEL	3	8114.94305739	2704.98101913
ERROR	29	26.96778013	0.92992345
CORRECTED TOTAL	32	8141.91083752	

MODEL F =	2908.82	PR > F =	0.0001

R-SQUARE	C.V.	STD DEV	BTU MEAN
0.996688	1.7778	0.96432539	54.24278788

SOURCE	DF	TYPE I SS	F VALUE	PR > F
GNP_B_72	1	7989.93113276	8592.03	0.0001
PRIN1	1	101.36096216	109.00	0.0001
BTU_P	1	23.65096246	25.43	0.0001

SOURCE	DF	TYPE IV SS	F VALUE	PR > F
GNP_B_72	1	53.38819379	57.41	0.0001
PRIN1	1	53.22564873	57.24	0.0001
BTU_P	1	23.65096246	25.43	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	0.73564829	0.97	0.3388	0.75645919
GNP_B_72	0.03387686	7.58	0.0001	0.00447099
PRIN1	-1.36027862	-7.57	0.0001	0.17980054
BTU_P	0.41734947	5.04	0.0001	0.08275592

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	26.96778013
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
FIRST ORDER AUTOCORRELATION	0.17008709
DURBIN-WATSON D	1.57898931

Table A.5. Regression results for model 3

DEPENDENT VARIABLE: RATIO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
MODEL	2	0.00030313	0.00015156
ERROR	30	0.00002888	0.00000096
CORRECTED TOTAL	32	0.00033201	

MODEL F =	157.46	PR > F = 0.0001

R-SQUARE	C.V.	STD DEV	RATIO MEAN
0.913021	1.6545	0.00098111	0.05930002

SOURCE	DF	TYPE I SS	F VALUE	PR > F
PRIN1	1	0.00016980	176.39	0.0001
RATIO_P	1	0.00013333	138.52	0.0001

SOURCE	DF	TYPE IV SS	F VALUE	PR > F
PRIN1	1	0.00001632	16.95	0.0003
RATIO_P	1	0.00013333	138.52	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	0.01622701	4.43	0.0001	0.00366376
PRIN1	-0.00063586	-4.12	0.0003	0.00015444
RATIO_P	0.71943607	11.77	0.0001	0.06112815

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	0.00002888
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
FIRST ORDER AUTOCORRELATION	0.05418952
DURBIN-WATSON D	1.86512684

Table A.6. Regression results for model 4

DEPENDENT VARIABLE: BTU_D

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
MODEL	3	76.71203362	25.57067787
ERROR	29	21.72413802	0.74910821
CORRECTED TOTAL	32	98.43617164	

MODEL F =	34.13	PR > F =	0.0001

R-SQUARE	C.V.	STD DEV	BTU_D MEAN
0.779307	65.8365	0.86551037	1.31463636

SOURCE	DF	TYPE I SS	F VALUE	PR > F
GNP_D	1	59.53735558	79.48	0.0001
PRICE_D	1	14.61784556	19.51	0.0001
FEDX_D	1	2.55683247	3.41	0.0749

SOURCE	DF	TYPE IV SS	F VALUE	PR > F
GNP_D	1	37.07684860	49.49	0.0001
PRICE_D	1	8.31663148	11.10	0.0024
FEDX_D	1	2.55683247	3.41	0.0749

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	0.04606926	0.16	0.8748	0.28984052
GNP_D	0.05350574	7.04	0.0001	0.00760539
PRICE_D	-5.51396122	-3.33	0.0024	1.65486380
FEDX_D	-0.00802298	-1.85	0.0749	0.00434267

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	21.72413802
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
FIRST ORDER AUTOCORRELATION	0.12303701
DURBIN-WATSON D	1.74557783

Mr. NELSON. Thank you very much, Dr. Hirst.
Mr. Copulos.

STATEMENT OF MILTON COPULOS, POLICY ANALYST, HERITAGE FOUNDATION, WASHINGTON, D.C.

Mr. COPULOS. Mr. Chairman, thank you.

I am Milton Copulos, director of energy studies at the Heritage Foundation. I sometimes feel like Daniel in the lions' den when I come down to this side.

However, Mr. Hirst has given a very good lead-in to a point that I want to make. I think we are all in agreement that conservation is a laudible goal and holds perhaps the greatest hope for short term reductions in energy consumption and improving our energy security.

The question really is how do we get there from here? In looking at one very salient statistic, I think the point is very graphically made.

Between 1973 and 1979, in spite of a host of Federal programs beginning with Project Independence and ranging through three national energy plans, what we found was the domestic demand for gasoline and crude oil rose in every year save one, 1974, through 1979. Then suddenly in 1979 something happened. What happened was we had the Iranian oil boycott which was followed with a very sharp price increase.

This in turn was followed by reductions which now lead us to the point where we are down as of last week 43.5 percent from our 1979 import level. Gasoline consumption is down about 16.4 percent in 2 years. If we compare 1982's performance, which is a very short time to compare of course, with the average for the last 5 years, we find that we have reduced our imports by 45.5 percent.

It is evident, quite frankly, that we have a case where the market has functioned and functioned extremely well to curtail demand. There are some that advocate that when you say a market approach what you are talking about is really a subterfuge for higher prices. However, I would make this point. When the Secretary of Energy first made the decontrol announcement he made the statement that gasoline prices would rise 3 to 5 cents over what otherwise would have been the case to stabilize that drop.

Unfortunately, in his statement he did not mention that what otherwise would have been the case included a 10 cent price rise that was following the OPEC action of the previous December.

What actually happened? We see that in fact gasoline prices did rise about only 2 to 3 cents over what otherwise would have been the case, stabilized, and now we are averaging 4.7 cents per gallon less than they did in the month following decontrol.

In short, the market worked, and worked very well.

We have also seen the response in drilling and reserve additions where last year oil and gas reserve additions exceeded consumption for the first time in two decades. That is not to say that we are going to be able to drill our way out of this but rather to say that both on the supply and demand side the market responds very well.

We then have to ask what can Government not do? We have seen many Federal programs. I think the BEPS program is one of the best examples of what not to do because you have all seen the stories about the bureaucrats with the light bulbs over their thermostat getting around the regs, or the zone systems where they chose the hottest spot where the Xerox was to set the air-conditioning or heating for a particular space.

What we do know is that there is some rational for a Federal program. There is pressure for it. What can you do? Actually the best thing the Government could do is get out of the way. The market will provide adequate conservation if we allow it to function and adequate conservation at a reasonable price.

There are other things, however, which can be done, but they are primarily at the State and local level. I think an example of a positive step taken by Government is in California, much as I hate to concede it sometimes. The State's utilities are allowed to include the cost of retrofitting conservation improvements in low income housing in the rate base.

This does two things. It mitigates the need for Federal or State expenditures to help weatherize homes. It, second, lowers the need to build expensive generatoring equipment for the utility, and, in the end, lowers the utility rates for all residents while at the same time lowers the amount of energy that needs to be conserved.

In terms of Federal actions, there is perhaps only one significant action the Federal Government could take to encourage greater conservation and greater supply at the same time. That would be to decontrol natural gas prices.

At present, natural gas prices are the only artificially controlled major factor in the energy market. As we have seen with all the control, lifting the Federal impediments does not mean higher prices. In fact, in all likelihood you would ultimately wind up with lower prices with the phased decontrol than you would under the current situation.

Thank you.

[The prepared statement of Mr. Copulus follows:]

TESTIMONY

OF

MILTON R COPULOS

Nearly a decade hs passed since the Arab oil boycott first shocked our nation out of its energy complacency and underscored the threat inherent in an undue reliance on imported energy. Since the embargo, we have witnessed a host of federal incentives intended to reduce that dependency ranging from Project Independence to the three National Energy Plans. Each was brought on with much fanfare, and the promise that at last the energy crisis would be resolved. All, however, failed to meet the rising expectations they generated.

Between 1973 and 1979, domestic demand for crude oil rose in every year save one, 1974. Demand for gasoline followed a similar patten except for a sudden drop in consumption which followed the advent of the Iranian oil embargo. Imports rose to a peak of 47.7 percent of U.S. consumption in 1977, and furnished 45.3 percent of our needs as recently as 1979.

As can be seen, in spite of an aggressive, and well-intended effort on the part of the Congress, and successive administrations to encourage conservation, little progress was being made to stem the tide of imports. In 1979, however, the situation began to change dramatically. According to figures fro the Energy Information Administration, for the latest reporting period, crude oil imports are down an amazing 43.5 percent from the same period in 1979. Gasoline consumption, although here I caution that the figures are not exactly comparable due to a change in the method by which they were computed, has dropped by 16.4 percent since

1979. In comparing 1982's performance with the average for the last five years, we find that imports have been reduced by an amazing 45.5 percent. Moreover, since stock levels have remained well within normal limits, we know that these import reductions are not, as some have suggested, the product of inventory draw downs. What is it then that we are doing right?

A clue to the answer to the question is found in data developed by General Motors. Prior to the 1979 Iranian embargo, and its accompanying price increase on the world market, GM felt it would not be able to attain the 1985 fleet fuel efficiency target of 27.5 miles per gallon, expecting instead to achieve an average mileage of around 26 mpg in that year. The reason for this was really quite simple; the buying public was simply not purchasing fuel efficient cars in sufficient numbers to make it possible to meet the target. Iran, however, changed all that. Now, as a result of fundamental changes in buying patterns, GM expects to not only meet, but to exceed the 1985 target, with fleet average of 30.5 mpg when the deadline occurs.

Interestingly, however, in Canada, where the government continues to keep gasoline prices down, GM is still looking at a fleet fuel efficiency average of 26 mpg, the same which we would have had without the change in buying patterns. So what happened here? The market was allowed to clear.

It is evident that the market, more than any other factor has been responsivle for the decline in U.S. oil consumption. Granted, the worldwide economic decline has contribute to short-term reductions in consumption, but the real strides have been in altering fundamentally, the way we look at energy cannot be denied. Remember, one a new piece of energy-saving equipment is installed, or a more efficient automobile is purchased, a basic change in the nation's capital stock has occurred. No matter how energy prices change, the efficiency improvement will remain.

There are some who contend that advocacy of a market solution is merely a subtrefuge for advocating higher prices. This is untrue. Although it is hard for those who do not believe in the market to accept, in the end, the market is the optimum means of achieving the lowest possible price, while ensuruing that adequate energy supplies are available. A case in point is gasoline. When the decontrol of oil prices was announced in January of 1981, the Secretary of Energy stated he expected prices to rise from three to five cents above what otherwise would have been the case, and then stabilize, and ultimately decline. Unfortunately, the announcement did not make clear the fact that an additional price increase of ten cents would take place due to the OPEC action that December. This added increment of price was beyond the control of the U.S. government, and constituted part of the rise in gasoline prices which would have occurred regardless of decontrol. What actually did happen then? The average price of a gallon of gasoline rose approximately twelve cents per gallon

by March of 1981, when it peaked, and the stabilized, and subsequently began to decline. It is now averaging 4.7 cents per gallong less than it did in the month following the announcement of decontrol.

The change in gasoline prices is actually far more significant than the nominal 4.7 cent decrease would indicate. Firts, at its peak, the rise in gasoline prices was less than expected, largely due to buyer resistance to the higher prices. Secondly, the subsequent decrease was larger than the portion of the increase attributable solely to decontrol. This means that in the end, all of the OPEC related increase could be passed through. Finally, the fact that the price of gasoline has declined in an economy which is suffering from continuing inflation means that in actuality the real decrease was larger than the nominal figures would indicate. In short, the prediction of stabalizing and then falling gasoline prices has been borne out by history. Nor has this been the only decontrol related market response which will serve to dampen prices. Another is drilling.

Thoughout the 1960s and the first part of the 1970s, exploration for oil and gas in the United States declined as firms souht new reserves overseas. With the decline in drilling came an accompanying decline in the level of U.S. proved reserves. This decline was accelerated by the stifling of incentives for domestic exploration caused by the imposition of price controls. With the lifting of those controls, however, a new surge of domestic

drilling began. By 1980, it became clear that the trend towards decreasing reserves was being reversed, and in 1981, researve additions exceeded consumption for the first time in two decades. While drilling is expected to slow somewhat this year due to the softening of oil prices, it should still be sufficient to maintain an increasing reserve base. The additions of oil and gas reserves, though, will not be enough in themselves. Other steps must be taken as well.

Among the most important would be the decontrol of natural gas prices. Contrary to the impression whcih was so pervasive a few years ago. we now know that the domestic resource base is vast. The primary impediment to it wider availability has been the continuing existence of federal price controls. While the Natural Gas Policy Act recognized this fact, and made an attempt to address it, the rapid changes in the world oil market made its price provisions outdated virtually as soon as it was enacted. It is time for Congress to bite the bullet and move to lift them. If it does, it will find, that as was the case with decontrol of oil prices, fears that prices would rapidly rise out of control were unfounded. In fact, it is likely that the price of gas at the wellhead would not exceed $4.50 per thousand cubic feet, on average.

In addition to the decontrol of gas prices, there are other things the government can do to spur greater domestic conservation. In many instances, however, these actions are best left to state

and local juridictions rather than the federal government. An excellent example of how state government can help to encourage conservation without directly interfering in marketplace is found in California. In that state, public utilities are now allowed to include the cost of retrofitting conservationg improvement on low-income homes. This allows the utility to avoid the necessity of building new and costly generating equipment, while still ensuring the continuity of service which is an integral part of its franchise. At the same time, low-income households become more efficient, and more habitable at no cost to the occupant. In the end, everyone benefits, and best of all, no government funds are needed. The only objection to this sort of program would be if it were mandatory, because mandatory measures actually work against conservation in the long run.

In order for conservation to occur, it must be the result of millions of individual decisions each tailored to meet a particular situation. Understanding this basic principle is essential to understanding why the market is the optimum device through which to encourage conservation. It allows the breadth of individual initiative to bring its full force to bear on the problem of improving energy efficiency, and ensure that it takes place to the fullest degree possible.

What then is left for the federal government to do? Mostly get out of the way. The dismal failure of the BEPS program is a classic example of what happens when we try to address conservation at the federal level. All that it did was create regulations that were ignored and paperwork that was a burden. What it did not do, however, is save energy.

Mr. NELSON. Thank you.
Mr. Wishart?

STATEMENT OF RONALD S. WISHART, DIRECTOR, ENERGY AND TRANSPORTATION POLICY, UNION CARBIDE CORP., NEW YORK, N.Y.

Mr. WISHART. Thank you, Mr. Chairman.

I am Ronald Wishart. I am director of energy and transportation policy of the Union Carbide Corp.

Union Carbide is a large energy user. We spent about $2 billion last year for energy and hydrocarbons as raw materials for our products. The principal lines of business are chemicals and plastics, industrial gases, graphite, the electrodes for making steel, Eveready batteries with which you are familiar, and many other smaller product lines.

My responsibilities include energy conservation program management for the corporation. During the period of 1974 to 1978 I served as chairman of the energy committee for the Chemical Manufacturers Association. During that period I became well acquainted with the needs and attitudes expressed by the many companies involved with that committee which collected reports from over 100—I think well over 80 percent of the energy consumed—in the chemical industry.

In that period and subsequently, I and people in my organization have been in frequent dialog with the Department of Energy representatives responsible for the industrial programs which were intended to facilitate more efficient use of energy by industry. I am pleased to comment on this proposed fiscal year 1983 budget for industrial energy conservation which would reduce expenditures in 1983 to $18 million down from $81 million in 1982 and $279 million in 1980.

I strongly support these budget proposals for three reasons: First, in the chemical industry and in other energy-intensive industry also the overwhelming deterrent to progress in energy efficiency improvement is lack of cash flow, not lack of will or interest or lack of technology.

Second, the need to reduce Government spending in all nonessential areas is paramount. It is clearly not a question of whether the DOE's programs have been well run or not. I have testified on that in earlier times. Or whether they are interesting technically, but rather whether they are essential to the national interest, and these programs are not.

Third, I approve the philosophy of this budget which contains the statement "Long term generic and technology based research, that is with respect to materials and catalyst research and instrumentation, and environmental research would continue to be supported."

Let me expand briefly on these three points. First, the problem is cash flow and not lack of technology. I agree wholeheartedly with many others that energy conservation activities are clearly still the lowest cost source of additional energy supplies. For example, if one is to take capital costs as a surrogate for price, which is a reasonable approximation for energy supplies, you will observe that to create the equivalent of a barrel of oil a day by synfuels the cost

will be well in excess of $60,000, synfuels from shale oil possibly $35,000, conventional drilling on the average about $30,000 or less, energy conservation at a 2-year payback from $13,000 to $23,000 depending on the energy source.

I submit there are still many investment opportunities in the energy-intensive industries providing 2-year paybacks which have not been invested in yet because of limited capital funds. This has been true and continues to be true despite the accelerated depreciation and R. & D. credit provisions in the new tax law because current business conditions do not support adequate profitability.

Despite that, the track record of American industry in achieving marked reductions in energy use per unit of output is good. In my own company the reduction is about 20 percent per unit compared to the 1972 base year, and several of our petrochemical plants have goals for 1985 of a 50 percent or greater reduction.

I have recently seen some data from the Chemical Manufacturers Association which indicates that the output of the industry since 1972 through 1980 has gone up 43 percent in physical volume, whereas the absolute appetite for energy has gone down. For natural gas it has gone down 20 percent.

Returning to the rank orderings of energy strategies by economic priority, I have argued that there is still a great deal of energy efficiency to be gained by industry. The present decline in the price of oil may appear to mitigate the pressure on industry to conserve, but it should be noted that price increases in natural gas and electricity are to be expected to continue.

For industry, natural gas is a much more significant source of energy than is petroleum. Electricity constitutes an increasing proportion of energy demand.

The energy-intensive energy-consuming industries have been hard hit by energy prices, by inflation in construction costs, and the poor national economy. The cash flow available for discretionary expenditures is markedly reduced from pre-1973 times in proportion.

It is still necessary to pursue business strategies to keep up with competition at home and abroad and the cost for environmental and human protection are obligatory. Both come ahead of the so-called working budget expenditures into which category many energy savings project expenditures fall.

I believe that if one favors support of energy conservation by Government, analagous to the subsidy of synfuels and subsidy of conventional oil and gas drilling, one is led to support continuation and expansion of investment tax credits for energy conservation expenditure.

If we are given a choice between applications R. & D. and targeted tax credits, the latter is clearly seen as a more powerful incentive.

Second, the need to cut Government expenditures is paramount. I cannot recall that there ever was a constituency in the chemical industry for Government funded application research. Process efficiency is an economic necessity for energy-intensive industry and it is a priority objective for architect engineers, research laboratories, and equipment vendors supplying the industry.

The tough decisions made in this budget are similar to those we frequently have been forced to make in industry. That is, programs which are less essential must be eliminated for the overall good of the enterprise when the issue is as clear as it is in this budget.

Federally funded applications R.D. & E. in energy conservation may in some instances accelerate the commercial use of new technologies, but we have always found that there is a competitive equipment vendor industry that will supply the market when the economics are appropriate. These vendors have experience in identifying market opportunities in terms of size and profitability and will invest their own funds when these criteria are satisfactory.

For example, a notable waste of electric energy occurs in the chemical and refining industries for lack of cost effective variable speed pump motors. Because of that lack, pumps are run at constant speed, and the output regulated by throttling valves, a very wasteful process.

We and others are cooperating with the electric machinery vendors in tests of new black boxes that can vary motor speeds. We usually look to such vendors for design advances, just as we look to ourselves or our competitors for improvements in process design.

Such a process improvement is our new Unipol process for the production of polyethylene, the world's most widely used plastic material. This process operates at less pressures and lower temperatures, saving at least 75 percent of the energy expended in the conventional high pressure processes. It produces a stronger, better product—therefore you use less of it—and is revolutionizing the polyethylene business.

Third, the philosophy of this budget makes sense. Support is continued for what is described as long range generic and technology base research. Over the years long range research has gravitated to universities and major research laboratory centers, away from industrial laboratories. Exploring physical phenomena, broadening the base of knowledge, leads to unpredictable results with benefits hardly calculable at the outset.

Such research should be carried forward, but my own experience tells me it flourishes better outside of industrial laboratories, which generally emphasize outcomes perceived directly beneficial to the company's particular product interests. From this base, industry can do what it is particularly effective at, translating theory into practice.

To summarize my views, the proposed budget eliminates applications research and development for energy conservation which has had little or no utility to my company or my industry. Our problem is inadequate cash flow for investing in energy efficiency improvements which are still very attractive to us.

In our opinion, the whole weight and direction of the Congress should be toward reducing nonessential expenditures. These expenditures are not essential in our view.

The philosophy of the budget makes sense. Entrepreneurs are providing application expertise and selling it, or affected industrial companies are doing so for their own good. Basic research into physical phenomena should continue to be supported, which can benefit society as a whole.

Thank you.

[The prepared statement of Mr. Wishart follows:]

Testimony Before House Subcommittee on Science and Technology
on the 1983 Budget for Department of Energy, Conservation and Solar

Good morning. I am Ronald S. Wishart, Director of Energy and Transportation Policy for Union Carbide Corporation. My responsibilities include Energy Conservation Program management for the Corporation. During the period 1974-1978 I served as Chairman of the Energy Committee of the Chemical Manufacturers Association. During that period I became well acquainted with the needs and attitudes expressed by the many companies active in the Committee, which collected reports from over 100 companies, to consolidate in an industry report to the government. In that period, and subsequently, I and people in my organization have been in frequent dialogue with the Department of Energy representatives responsible for the industrial programs designed to facilitate more efficient use of energy by industry.

I am pleased to comment on the proposed fiscal year 1983 budget for Industrial Energy Conservation which would reduce expenditures in 1983 to $18 MM, down from $81 MM in 1982 and $279 MM in 1980. I strongly support these budget proposals for three reasons.

1. In the chemical industry -- and in other energy intensive indust. also, the overwhelming deterrent to progress in energy efficiency improvement is lack of cash flow not lack of will or interest -- nor lack of technology.

2. The need to reduce government spending in all non-essential areas is paramount. It is clearly not a question of whether the DOE's programs have been well run or not, or whether they were interesting technically, but rather whether they are fully in the national interest. These programs are not.

3. I approve the philosophy of this budget, which contains the statement "Long term generic and technology base research (e.g., materials and catalyst research and instrumentation) and environmental research would continue to be supported."*

Let me expand briefly on these three points.

First, that the problem is cash flow, not lack of technology. I agree wholeheartedly with many others, that energy conservation activities are clearly still the lowest cost source of additional energy supplies. For example, if one is to take capital costs as a surrogate for price, which is a reasonable approximation for energy supplies, you will observe that to create the equivalent of a barrel of oil per day by:

Synfuels from coal requires an investment of above $60,000

Synfuels from shale oil possibly $35- or $40,000

Conventional drilling, on average about $30,000

Energy conservation at a two-year payback -- $13,000 to $23,000 (depending on energy source)

*Non-Nuclear Energy Research & Development. Functional Code 271, p. 97, Budget.

I submit that there are still many investment opportunities in the energy intensive industries providing two-year paybacks, which have not been invested in yet because of limited capital funds. This has been true, and continues to be true despite the accelerated depreciation and R&D credit provisions of the new tax law because current business conditions do not support adequate profitability.

Despite that, the track record of American industry in achieving marked reductions in energy use per unit of output is good. In my own company the reduction is about 20%/unit compared to a 1972 base year, and several of our petrochemical plants have goals for 1985 of 50% or greater.

Returning to the rank orderings of energy strategies by economic priority, I have argued that there is still a great deal of energy efficiency to be gained by industry. The present decline in the price of oil may appear to mitigate the pressure on industry to conserve, but it should be noted that price increases in natural gas and electricity are to be expected to continue. For industry, natural gas is a much more significant source of energy than is petroleum, and electricity constitutes an increasing proportion of energy demand. The energy intensive, energy consuming industries have been hard hit by energy prices, by inflation in construction costs, and the poor national economy, so that cash flow available for discretionary expenditures is markedly reduced from pre 1973 times. It is still necessary to pursue business strategies to keep up with competition at home and abroad, and the costs for environmental and human protection are obligatory. Both

come ahead of the so called "working budget" expenditures into which category many energy saving project expenditures fall. I believe that if one favors support of energy conservation by government analagous to subsidy of synfuels and conventional oil and gas drilling, one is led to support continuation and expansion of investment tax credits for energy conservation expenditure. If we are given a choice between applications R&D and targeted tax credits, the latter is clearly seen as a more useful expenditure.

Second - the need to cut government expenditures is paramount. I can't recall that there ever was a constituency in the chemical industry for government-funded application research. Process efficiency is an economic necessity for energy intensive industry, hence a priority objective for architect engineers, research laboratories and equipment vendors supplying the industry.

The tough decisions made in this budget are similar to those we've frequently been forced to make in industry. That is, programs which are less essential must be eliminated for the overall good of the enterprise when the issue is as clear as it is in this budget. Federally funded applications RD&E in energy conservation may, in some instances, accelerate the commercial use of new technologies, but we have always found that there is a competitive equipment vendor industry that will supply the market when the economics are appropriate. These vendors have experience in identifying market opportunities in terms of size and profitability and will invest their own funds when these criteria are satisfactory.

For example, a notable waste of electric energy occurs for lack of cost effective variable speed pump motors in the chemical and refining industries. Because of that lack, pumps are run at constant speed, and the output regulated by throttling valves, a wasteful process. We - and others - are cooperating with electric machinery vendors in tests of new black boxes that can vary motor speeds. We would usually look to such vendors for design advances, just as we'll look to ourselves or our competitors for improvements in process design.

Such a process improvement is our new Unipol process for the production of polyethylene, the world's most widely used plastic material. This process operates at less pressures and lower temperatures, saving at least 75% of the energy expended in the conventional high pressure processes. It produces a stronger, better product and is revolutionizing the polyethylene business.

Thirdly, the philosophy of this budget makes sense. Support is continued for what is described as "long range generic and technology base research." Over the years long-range research has gravitated to universities and major research laboratory centers, away from industrial laboratories. Exploring physical phenomena, broadening the base of knowledge, leads to unpredictable results with benefits hardly calculable at the outset. Such research should be carried forward, but my own experience tells me it flourishes better outside of industrial laboratories which generally emphasize outcomes perceived directly beneficial to the company's particular product interests. From this

base, industry can do what it is particularly effective at -- translating theory into practice.

So -- to summarize my views.

The proposed budget eliminates applications research and development for energy conservation which has had little or no utility to my company or my industry. Our problem is inadequate cash flow for investing in energy efficiency improvements which are still very attractive to us.

In our opinion the whole weight and direction of the Congress should be toward reducing non-essential expenditures. These expenditures are not essential in our view.

The philosophy of the budget makes sense. Entrepreuneurs are providing application expertise and selling it, or affected industrial companies are doing so for their own good. Basic research into physical phenomena should continue to be supported, which can benefit society as a whole.

Thank you.

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March 15, 1982

BIOGRAPHY

RONALD S. WISHART, JR.

DIRECTOR, ENERGY AND TRANSPORTATION POLICY
UNION CARBIDE CORPORATION

Mr. Wishart was born in Brooklyn, New York, March 1, 1925. He is a graduate of Rensselaer Polytechnical Institute where he received the degree of B.Ch.E. in 1948.

He jointed Union Carbide in 1948 as an engineer at the Tonawanda Laboratory at the corporation's Linde Division. From 1951 to 1956, he was identified with silicones sales and marketing in Cleveland and Chicago. When the corporation's former Silicones Division was established, he was appointed Assistant Midwestern Regional Manager in 1956, General Manager in 1963, and Division President in 1964. Early in 1967, he became President of the former Chemicals and Plastics Development Division, following which he joined the former Coatings Intermediates Division as its President in 1968. He was appointed Group Manager for Chemicals and Plastics when that area of the corporation's business was restructured early in 1972. He became Director, Feedstock and Energy Policy for the corporation in August 1973, and continued to direct commercial development activities concerned with the long-term future of Chemicals and Plastics worldwide. In 1976, he became Director, Energy and Transportation Policy - Energy, Supply and Services Group.

He has been Vice President, Marketing Division, and a director of the American Management Association, and is now a member of the AMA President's Council. He is a member of the Chemical Manufacturers Association, American Chemical Society, Society of Chemical Industry, Alpha Tau Omega, Tau Beta Pi, Phi Lambda Upsilon, and Pi Delta Epsilion. He is Vice President, a Member of the

Board of Directors, and on the Finance Committee of the National Petroleum Refiners' Association. He is a member of the NAM Energy Conservation Task Force and Chairman of the their Subcommittee on Public Awareness. He is a member of FERC (Federal Energy Regulatory Commission) Advisory Committee on Revision of Rules of Practice and Procedure. He is past Chairman of ELCON (Electricity Consumers Resource Council). From 1974-1979 he was Chairman of the Energy Conservation Committee of the Chemical Manufacturers Association. He is former member of the Federal Power Commission Advisory Committee on Natural Gas. He is a member of the Lords Valley Country Club and has served as its President and member of their Board of Governors. He is a trustee of the Jennie Clarkson Home, and a former trustee of the White Plains Presbyterian Church.

Mr. Wishart is the author of a National Electrical Manufacturers Association prize-winning paper (1948) titled, "History of Electric Arc Welding," and coauthor of patents on Silicones products and uses. He is also author of a chapter titled, "The Marketing Factor" for am American Management Association publication, CORPORATE GROWTH STRATEGIES, plus numerous articles and speeches on Eenrgy and Transportation Policy matters.

During World War II, Mr. Wishart served as a volunteer ambulance driver with the Indian Army for the American Field Service.

He lives at 40 Axtell Drive, Scarsdale, New York, and is married to the former Eleanor Parrish Dooley. The Wisharts have four children.

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Mr. HARKIN [acting chairman]. Thank you very much, Mr. Wishart.

Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman.

I would like to follow up, Mr. Wishart, on your last statement. I am trying to get in my own mind a little better understanding of what you are saying.

You indicated your support for the administration's industrial energy conservation budget request, and you further indicated that your own problem in investing in more energy efficient equipment was inadequate cash flow—I believe I am quoting you correctly—and not the lack of technology.

In that respect, to what extent will the new tax incentives in the Economic Recovery Tax Act help stimulate new investment in more energy efficient equipment?

Mr. WISHART. I think directionally they certainly will, but in a untargeted way. That is they are not aimed at any particular thing.

I suspect that present business conditions will change. I hope they do. Therefore, in fact the tax credit will be beneficial and add to cash flow.

However, the priority ranking of the expenditures, will still control investment. That is the ones to achieve business strategies and, second, to meet the obligatory expenditures and, third, to do discretionary things. That ranking will continue. To the extent that investments in retrofitting old plants are discretionary, and they are, the effect on energy efficiency be beneficial but quite indirect.

Mr. WINN. Thank you very much.

Mr. Anderson, I think we probably would all agree with your recommendation that we need to have a much stronger energy R. & D. capability than we certainly have at the present time.

The question is, I suppose, how can we attain this goal. I was wondering if ORNL had conducted any studies on the impacts of the tax incentives that are contained in the Economic Recovery Act on increased energy R. & D?

Mr. ANDERSON. We have not. I am not aware of any that have been made. I can report what individuals from industry tell me about that. I do not represent this as a common view, but one that I hear quite often is that it is marginally effective.

One reason of course is that those industries that are in very bad shape and therefore need research and development worst of all do not pay any taxes to start with. They are losing money. It is not a very big incentive to give tax benefits under such conditions.

However, I am not aware of a study that actually looks at that question. I just report on what I hear and feel is the effect.

Mr. WINN. Then you do not believe that the R. & D. tax credits that are contained in this legislation will play a particularly significant role in stimulating future R. & D., or am I misreading that?

Mr. ANDERSON. I would not go that far. I think when profitability returns to some of the industries that are in worst need of research and development the tax incentives might help. Surely it must be a positive effect, but not very big at present.

Mr. WINN. Mr. Copulos, let me ask you about the Heritage Foundation. All last week this committee heard about the impacts of oil decontrol and tax incentives on energy production and consumption patterns in the United States. Has the Heritage Foundation conducted any studies in any of these areas?

Mr. COPULOS. Sir, there are two things we have done. In reviewing the effect of the phased decontrol of prices the statistics are very stunning in that they show that prior to the phased decontrol of oil prices we were experiencing decreasing supply and increasing demand and rising prices.

In looking at it, we find that only with decontrol did the prices stabilize and begin to decline. In fact, an analysis we are looking at currently that is not yet complete at least in a preliminary sense indicates a market clearing price for crude oil in the absence of controls which would have been probably $22 or $23 a barrel, which means that the consuming public of the United States has in the end paid far more for their crude oil than they had to. The same may well be true in the long run of natural gas. We also believe the market clearing price for natural gas is probably going to be somewhere around $4.50 a thousand cubic feet at the wellhead.

Mr. WINN. Do you believe that the marketplace could pick up the development of the conservation technologies if the Federal support is dropped?

Mr. COPULOS. I am sure that it will. The simple fact is that the marketplace better than any other factor can determine it.

Now one thing I did suggest is there are some positive things Government can do both to encourage conservation. One I know of is in California where utilities are allowed to go back and retrofit low income housing with storm windows, insulation, what have you, and include that in their rate base.

The alternative to them is to build base load capacity, which is very expensive, and raises everybody's electric bill.

In the end, by allowing them to do this, you eliminate the need for a Federal or State conservation program which would go out and do these things. You have reduced the overall cost of generating electricity to every consumer and the people who otherwise would not have been able to afford these improvements wind up having them installed in their homes.

I would, however, object to making it mandatory. I think that is an option they should retain.

Similarly, another thing we have looked at is the exclusion. These are mostly State actions because we have to realize conservation is a result of millions of decisions in the marketplace and what works for one individual in a specific circumstance may work for no one else. That is one reason the market functions so well.

Another thing we have suggested is to exclude from the property tax base the cost of the conservation improvement both for industry and individuals. That means if a company wants to go in and install additional equipment to help conserve energy, and say it is $10, $15, or $20 million, that would not automatically raise their property tax assessment by whatever the amount is. Similarly, for a homeowner who wants to go out and spend $3,000 to insulate his attic and put on storm windows, it is not going to add $200 or $300

to his annual property tax bill, negating the value of the savings in energy cost.

Mr. WINN. We have an interesting phenomenon developing in some parts of the country. We are getting a response from various utilities who are saying that's due to increased conservation, they have to ask for price increases since their business is down, and demand is down, they indicate that they have certain fixed prices or expenses, and now they are having to request price increases from appropriate State officials to compensate for this phenomena.

What is the answer to that? Here is a case where the consumer is getting hit again.

Mr. COPULOS. There are three aspects of that. One is we are beginning to realize, especially in building the large base load generator plants, nuclear, coal, and what have you, that people only remembered half of their economics when they looked at economies of scale.

Economies of scale actually represent a curve. You kept saving money as it got bigger, but once you pass the peak, after a certain point, it starts getting to be less efficient to have a very large facility. It has been suggested that both in terms of some nuclear plants and some coal-fired plants we have diseconomies of scale now.

The notion of allowing them to include conservation improvements in their rate base, frankly, is addressing part of the feedback that you are getting, Congressman, where they are saying, "Look, if we cut back too much, we are going to lose money and ask for a rate increase." That means the base load capacity built is not justified.

If you allow them to include the conservation, that offsets it and possibly will allow them to mothball some of that capacity and put it in reserve for the future.

Mr. WINN. That is a very interesting concept.

Thank you, Mr. Chairman.

Mr. HARKIN. Thank you, Mr. Winn.

Mr. Wishart, on page one, you said:

> I am pleased to comment on the proposed fiscal year 1983 budget for industrial energy conservation which would reduce expenditures in 1983 to $18 down from $81 million in 1982 and $279 million in 1980.

Do you mean the whole conservation program? The industrial conservation program is zero.

Mr. WISHART. I had to dig out those figures when I got the request. I think industrial energy conservation, the applications R. & D. is zero, right?

Mr. HARKIN. The whole industrial program is zero.

Mr. WISHART. You continue to support basic research, do you not? That money which is being spent is being spent on long term generic and technology-based research. There is $18 million in there, is there not?

Mr. HARKIN. The $18 million is across the board, but you are saying is some of it will go for industrial conservation. Do we know how much?

Mr. STEINWAY. About $2 million.

Mr. HARKIN. About $2 million.

Mr. WISHART. About $2 million will go for what?

Mr. HARKIN. Industrial energy conservation.

Mr. WISHART. Yes, applications research.

Mr. HARKIN. No, as I understand it total industrial energy conservation research will be around $2 million. So it is not $18 million. It is $2 million.

Mr. WISHART. We may not have any disagreement at all because I think the kind of research that in my reading I identified with the $18 million would certainly not be described as industrial applications research. It would be scientific research, not engineering.

Mr. HARKIN. It is still not $18 million. I do not know what the correct figure is.

Mr. WISHART. Whatever it may be.

Mr. HARKIN. It is much less. It is closer to zero than it is to $18 million.

Mr. WISHART. In the applications, correct. I think that is proper.

Mr. HARKIN. I think in the whole industrial program.

Mr. WISHART. I cannot solve that problem.

Mr. HARKIN. Can staff enlighten us? Is he right or am I right?

Dr. FRANKEL. The full $18 million is now placed in a category called "conservation research." It is not broken down according to end use application. The best breakdown that we can get of that is about $7.5 or $8 million worth of battery research, about $3 or $4 million worth of research that applies to the building sector. Then there is ceramics and heat exchanger research that can apply equally to engines for transportation or for industry. What is left over is about $5 million that can be split between transportation and industrial applications, although it is not broken out. Of that $18 million, we have left about $5 million that could be either transportation oriented or industrially oriented.

Mr. WISHART. My source was Non-nuclear Energy Research and Development Functional Code 271, page 97, of the budget analysis. It was opaque to me about how the distribution of the $18 million went. I could not tell that from the numbers I had.

What I did perceive was the language I quoted and with which I agree.

Mr. HARKIN. Can you illuminate any further? You had a figure of $2 million. How did you get that?

Mr. STEINWAY. We asked DOE to give us a breakdown of how the generic research program funding would be allocated among all the various end use sectors. Off the top of my head, I thought they indicated that about $2 million in generic research was diverted for industrial R. & D. There would be some generic research in the buildings and communities areas, and in the utility and transportation sectors as well.

Mr. WISHART. Support for basic research would come from several sources, would it not? It would show up in universities and Oak Ridge National Laboratory and places like this.

Mr. HARKIN. Of this breakdown all I have is $1.06 for heat pumps under industrial.

Mr. STEINWAY. I thought there was some funding in the materials area.

Mr. HARKIN. It is $1.06. We finally have it. It is right here. It is $1.06 billion for industrial energy conservation.

You said you strongly support these budget proposals when it was $18 million. Do you strongly support the $1.06 million?

Mr. WISHART. I strongly support a reduction in applications research for the reasons I cited. I strongly support support of generic research into physical phenomena.

Mr. HARKIN. According to the DOE industrial program, the chemical industry spent more than 10 times as much on R. & D. in 1978 than the steel, aluminum, paper, and textile industries. Therefore, your statements about the chemical industry's need for Federal assistance in energy R. & D. would not necessarily apply perhaps to the textile, paper, or aluminum or steel industry.

Mr. WISHART. Not necessarily, but I think they certainly have the option of enhancing their competitive capability through research. They also have the option of licensing other technology.

I know some steel people very well. They are a principal customer of ours. They do not think they need exotica. They do not need very new ideas. What they need to do is find enough money to invest in continuous casting and that sort of thing, which is established technology which they think came out of the United States but is applied in places where the steel industry was bombed out or where a strong national commitment to a fundamental industry as reflected in other approaches.

It was not an investment in R. & D. It was an application by the enterprise of money to that particular approach.

Mr. HARKIN. You are saying that the steel industry basically needs more cash to invest in energy conservation.

Mr. WISHART. I do not know what sort of management judgment was applied earlier when they did not.

Mr. HARKIN. However, you are saying they need it now.

Mr. WISHART. They need to modernize their facilities for sure.

Mr. HARKIN. Is that what you think, Mr. Copulos?

Mr. COPULOS. Yes.

Mr. HARKIN. How do you then explain U.S. Steel? We gave them all these big tax breaks last year. They have more money than they know what to do with, and they went out and bought Marathon Oil Co.

Mr. WISHART. I really would not comment on that because I do not understand it.

Mr. HARKIN. I do not understand it either. This is a question I want to get into. A recent draft study for OTA by Dartmouth College finds that tax credits for industrial conservation will improve the profitability of industry but will not induce much conservation. Yet you are very committed to tax credits.

Basically what we gave U.S. Steel last year was in essence tax credits, a lot of tax credits, and they took their tax benefits and used them to increase their cash situation so they could go out and bid up the stock of Marathon Oil to almost twice what it was worth.

Mr. WISHART. Without disagreeing with you on the latter point, I would disagree with what I thought I heard about Dartmouth's statement about energy conservation. I think we have done a good job there and we think we can do an awful lot more.

Mr. HARKIN. Your chemical industry has.

Mr. WISHART. Yes.

Mr. HARKIN. For some reason—I do not know why—you have been good at it. I am talking about these other yokels.

Mr. WISHART. Other people have been effective in energy conservation, too. The overall industrial track record is pretty good.

Mr. HARKIN. Not nearly as good as you have been, though; not like the chemical industry.

Mr. WISHART. There are reasons.

Mr. HARKIN. I would like to know what the reasons are.

Mr. COPULOS. Mr. Harkin, I would like to comment on that if I can.

I think there is recognition of the fact that the investment pattern in the United States in the past 10 years has been very poor, especially in basic plant equipment, but that has been more a matter of national practices that focused on short-term profitability which I think arose out of some management techniques of years past.

However, it does not change the fact that there is a need for basic research. If I may, in the case of Marathon, being somewhat familiar with that, we have to bear in mind the fact that they did not bid up the stock to twice what it was worth and they bought it at about two-thirds of its book value when one considers the value of the reserves they picked up. Perhaps some of the motivation might have been is the cash flow that will occur once the North Sea oil field is fully on line. I do believe that was an element, which is not to excuse their going out and buying Marathon instead of investing in new plant and equipment.

Mr. HARKIN. Especially when they bid up the stock like they did.

Mr. COPULOS. You talk about steel and textiles and so on. Some of the industries are certainly among the industries which have suffered the worst at the hands of foreign competition and largely due to a lack of investment.

However, I would suggest this to you, sir. They also were industries that were protected for a number of years by various trade barriers. If they had to trade in a free environment, they might have been sparked to make the sort of investments in years past that would have prevented some of the troubles today.

In every case, when we try to interpose a government between ourselves and the market, when we try to make those myriad decisions that go on on a day-to-day basis, inevitably we foul things up. Quite frankly, the best thing we can do is get out of the way.

Mr. OTTINGER. Would the gentleman yield?

Mr. HARKIN. I would be delighted to yield.

Mr. OTTINGER. I would like to welcome my constituent, Ron Wishart, and recognize the tremendous contribution he has made in energy conservation. He is a leader in the industrial field in that effort.

Would we not be better by far giving targeted tax credits for actually achieved conservation as we sought to do in the Wallop bill which I cosponsored rather than generalized tax credits?

Mr. WISHART. I think so.

Mr. OTTINGER. I see Mr. Copulos shaking his head. We will give you a chance to respond.

Mr. COPULOS. Mr. Ottinger, I have to disagree because again we are getting back to the basic problem which is we are trying to direct the market.

We tried this with price and allocation rules on crude oil and we turned a 5 percent physical shortage into a 30 percent shortage at the gasoline pumps. We have tried to do it time and again. The simple fact is when you consider the complexities involved the best thing we can do is allow the market to function as free of impediments as possible if we stop and look at what happened after 1979.

Mr. OTTINGER. We do not have infinite amounts of money up here to forgo in taxes or to give for specific subsidies. We followed your advice and we cut taxes $750 billion and now we are faced with a terrible economic situation. I did not like the advice to begin with, but now that it is playing out, I like it even less.

It seems to me that with the limited resources we have if we are going to continue to run the essential functions of Government the best thing we can do is target our incentives to the things the country really needs rather than just spewing away money for preparations. That seems to me to be unconscionable.

Mr. COPULOS. Sir, I think first of all the tax cuts that went into effect on the corporate side were perhaps even in some ways in excess of what was originally proposed if I remember correctly. I am not an expert on it and I may be wrong, but please correct me if I am wrong.

Let us just look at one specific case in point if we may as a for instance, alcohol fuels.

Mr. OTTINGER. Was it GE that was getting money back from the Government because of the tax breaks that were given. With billions of dollars of profits they not only do not pay taxes but they get refunds.

Mr. COPULOS. There again I do not think that was the original intent. However, let us take a look at a targeted program to see how that compares, alcohol fuels.

I happen to be a fairly strong advocate of alcohol fuels. It was kind of interesting. About 4 years ago you had some farmers out in Iowa who got together and said, "We have to do something with our surplus corn. Let us see if we can make alcohol out of it because we remember Henry Ford used to do that."

They had a nice little industry kind of perking along there. I think they made their first mistake when they went out and sought the State 4-cent credit on their gasoline tax. That notwithstanding, with a fairly modest incentive they were perking along nicely.

Then along came the Government who said they were going to give them loan guarantees and do all these other wonderful things to help. One of the four great lies is: "Hi. I am from the Government and I am going to help you."

What happened, sir, is that many loans that were pending to finance plant construction—I know of 10 specific examples myself—wound up saying, "We will not loan you the money right now because we want you to go get some of that Government money and a Government loan guarantee."

The result was when they finally did go back 2 years later the rate they had to pay was not the 10 or 11 or 12 percent but 22 per-

cent. It cost them more. In the end they did not get the Government guarantee anyway. All it did was slow down the growth of the industry.

Mr. WISHART. May I respond to that?

Philosophically I am sure if we discussed this topic for awhile we would find ourselves in a very similar position. My support for the Wallop bill is a reflection of what I perceive to be an inappropriate subsidy pattern for energy in general. That is there is quite a bit of money still being employed to support synfuels which are a long way down, as I pointed out in my testimony, the economic ladder from energy efficiency improvement.

There is a very significant subsidy for oil and gas drilling. All I am suggesting is if one is going to look at the general subject of a Government role in the subsidization of energy we have the cart before the horse.

If you are not going to subsidize any of it, that sounds to me like it might be a pretty good idea, too, but if you are going to juggle the money around, I think the better place to put it is in the least cost option.

Mr. OTTINGER. You could not have expressed my views better than if I had done it myself. I would be delighted to see all the subsidies eliminated. We proposed a budget to do that and it did not get to first base. So long as you are going to have these huge subsidies, oil, gas, nuclear, all the studies made indicate conservation is the prime option. That ought to receive the priority in the Federal ball park. I take it we are not too far apart on that. Am I correct?

Mr. COPULOS. Mr. Ottinger, if you would agree with me that tomorrow we will zero budget the synthetic fuels corporation, we will eliminate all other similar subsidies and penalties, we will also eliminate the windfall profit tax, and other things that unjustly take away economic rent so that everybody is subject to the same taxes and the same situation in any business, I would happily agree with you, sir.

Mr. OTTINGER. I am very close to being there, but I do not see any possibility of our actually doing it. I think the windfall profit tax is a tremendous failure, not necessarily because of the tax itself but because the promise of where those revenues were going was never fulfilled. If you are going to have that tax and if it is going to be paid by consumers, then the people who are going to be hit worst at least ought to get it back. It did not work out that way. I would be happy to see the whole kit and caboodle done away with.

Mr. COPULOS. Sir, then we are in agreement.

Mr. HARKIN. Mr. Anderson, did you have something you wanted to add?

Mr. ANDERSON. Yes. Thank you very much. I would like to plug my wares for a moment.

I think an important issue at this hearing is research and development. It is agreed that there are technologies available today that are cost effective for the country to implement. That includes energy use technologies as well as energy supply technologies.

There are certainly possible benefits from having programs to encourage that use further. I do not deny that.

However, we should not confuse those benefits with the possible benefits from research and development. It would be nice if we

could include those because it would make research and development look a lot better, but that is not the thing we should do.

We were careful in our study that suggests the country could spend $13 billion a year on conservation R. & D. to exclude benefits achievable through other measures.

Maybe Mr. Wishart would correct me on this, but I disagree with the point that because we already have good technologies we should, therefore, not develop better technologies. We should replace our 60-year-old steel mills with new steel mills incorporating Japanese technology which they took from us 25 years ago and, therefore, always be just one step behind.

What is wrong with this country being the leader? What is wrong with us building steel mills that are better than the Japanese?

I really am appalled at the prospect of competing in a world in which the other countries have thrown together their government, their industry, their national labs, and their universities in a cooperative way to compete in international markets, and we respond to that challenge by erecting very strange philosophical barriers between all of our institutions. I just do not think that is right. I think we are in the same boat and we ought to put our efforts to solving the national problems and rise above these great principles.

Mr. HARKIN. Thank you.

I just wanted to ask you, Mr. Anderson, about this $13.7 billion. What would you spend that money on? You said that is the level that could be justified. What would you spend that on?

Mr. ANDERSON. Mr. Harkin, as I said, I certainly would not go out and try to spend that kind of money now because the country simply does not have the research and development capability to do so effectively. We ought to work toward a much stronger R. & D. establishment. I do not want to suggest that $13.7 billion is the magic number, but I am saying that it is much, much larger than we are spending at present.

The first thing the country ought to spend money on, the biggest item, is transportation, cars and light trucks. That is the biggest single cost item as far as energy. Nationally that would be No. 1.

No. 2 is simply building heating. If I were running the Government program, I think I would spend most of the Government money on building heating because I believe that industry has quite good R. & D. capability in transportation. Perhaps they are not doing enough. We have seen the consequences of that, by the way, over the past decade or so.

For the Government, I think the buildings sector, just the heating question, would be the biggest item, not the only but the biggest.

Mr. HARKIN. Let me followup. What would you do in transportation?

Mr. ANDERSON. There are so many opportunities that it is difficult to know where to start. For example, we found that a 10- to 15-percent reduction in the weight of cars would be worth $240 billion. That includes the use of new materials.

Mr. HARKIN. Over what period of time?

Mr. ANDERSON. Over the next four decades.

It is a long shot possibility, but there are concepts for advanced diesels that have very high efficiency. These would be applicable mostly to large trucks which become a much larger part of transportation energy use in the future than it is today. Transportation of goods goes up with GNP, whereas transportation of people tends to go up more with people.

Transmissions, infinitely variable transmissions, is another excellent possibility, especially for small cars.

Air-conditioners are not great energy users because one does not use them that much, but they are great power sappers. Anyone that has a small car with an air-conditioner knows that. Improved performance of the car with a better air-conditioner, perhaps an absorption air-conditioner, is a possibility.

Mr. HARKIN. Dr. Frankel wanted to ask a question.

Dr. FRANKEL. A recent study done by the Department of Energy Policy Office said: "A predominant market response to higher energy prices has been curtailment of energy consumption, declining labor productivity, lower standards of living, and slowed economic growth. Energy efficiency improvements by way of capital investments have had secondary effects only."

If those are in fact the effects of the market response to higher energy prices, if you looked at the study and found that was actually true, would you still recommend to us, Mr. Copulos and Mr. Wishart, a purely market response to the higher energy prices?

Mr. WISHART. I have seen such good work out of the Department of Energy that that quotation surprises me. I think Cathy Abbot's study, for example, on natural gas deregulation is a good document.

I really think that this is hardly an item for disagreement. Part of the plight of the steel industry is the efficiency of the chemical industry. The automobiles are built of plastic, not steel. There is big growth in the explosion of the urothanes of the 1960's. There is a product change.

This generalization about the economy of the world associated with the shocks of dramatic increases in oil prices, I think that is transparently true. You have changed, what did you say, to 15 percent of the GNP that is energy cost—I had 10 in my own figures—from about two in 1972. That is a huge transfer of funds. That is a huge income transfer from users to producers, and we are users.

It requires us to drive up our prices, but it also requires us to change our way of looking at things. We have plants that were designed for 20 cent natural gas. They are buying $3.50 natural gas today. They are designed differently. As a matter of fact, their processes are different.

That Unipol process I talked about, we no longer pump ethylene up to 60,000 PSI. It goes to 300 PSI, and we produce better polyethylene and save 75 percent of the energy. However, the changes are a little slow because it takes a few years for these new directions in technology to lead to new processes. It takes a few more years for plants to be built.

I guess that is a long term energy conservation effect or a long-term price elasticity response. I think if you suddenly take an awful lot of money out of somebody's pocket and he did not have a

whole lot to begin with, it takes him a while to change his life style, but he will.

I have a sister-in-law who spent $3,000 heating her house in Plymouth, Mass. last year with oil, and $600 this year because she put in a coal airtight stove and burned coal. We respond.

Mr. COPULOS. There is an example I think that can cite more specifically how this has an effect on the public at large.

Prior to the 1979 price increases which followed in the wake of the Iranian oil embargo, General Motors estimated they would not be able to meet the 1985 fuel efficiency target of 27.5 miles per gallon. The simple fact was that people were not buying efficient cars. They did not want them.

In the aftermath of the embargo, however, their latest projections indicate that the fleet efficiency average for GM's cars in 1985 will be 30.5 miles per gallon, exceeding the original projection by 4½ miles per gallon. That is an incredible change.

Mr. HARKIN. 1985?

Mr. COPULOS. In 1985, and that exceeds the target by three miles per gallon, purely because of market change.

In Canada, where they have followed a low cost energy policy and continued to keep their gasoline prices below what the market clearing price would have been, Canada, which has had buying patterns identical to the U.S. historically for automobiles and essentially buys the same cars, still is going to have that 26 mile-per-gallon average in 1985.

The fact is that because they have not allowed the market to function they are not going to conserve. In this country we are.

We also are on the verge of a huge turnover in our automobile stock. The average car in this country is 6½ years old. People are getting to the point where they are going to trade them. The ones that are going to trade come from that 1974 through 1978 model year series which were the least efficient automobiles the country produced.

I think we are going to see tremendous strides. Just as Mr. Wishart said, it takes a little time for these things to set in.

Mr. HARKIN. I can tell you that at the price of cars and with today's interest rates, people are going to hold onto those cars a long time.

Thank you very much. You have been a very good panel. We appreciate your testimony.

Mr. HARKIN. Next I would like to call Mr. Arthur Jackson, director of wind energy programs for Hamilton Standard; Mr. Danny Digiovacchino, manager of wind energy programs, General Electric; Mr. Robert D. Lacy, project manager of the Heber binary cycle project, San Diego Gas & Electric Co., and Dr. Lawrence Germain, deputy associate director, energy programs, Los Alamos National Laboratory.

We are going to talk about wind and geothermal so would you all come up and take your seats.

We have copies of all of your prepared statements and, without objection, they will all be made a part of the record in their entirety. I would like to ask you to summarize as best you can rather than perhaps reading verbatim the entire testimony if that would be all right with all of you.

First, I call upon Arthur Jackson, director of wind energy programs, Hamilton Standard. We will insert a copy of your written testimony in the record.

STATEMENT OF ARTHUR JACKSON, DIRECTOR, WIND ENERGY PROGRAMS, HAMILTON STANDARD, WINSOR LOCKS, CONN.

Mr. JACKSON. Mr. Chairman, we appreciate this opportunity to discuss our views regarding possible continued Federal Government support of wind energy development as related to the fiscal year 1983 Department of Energy budget authorization.

Hamilton Standard has not been a contracting participant in the broad DOE/NASA wind energy program for several years. Our views, therefore, probably have a somewhat different perspective compared to those who have been more deeply involved with Federal Government development contracts, although perhaps not entirely at odds with them.

I have a very long statement and what I am going to do now is jump ahead and summarize with a series of one liners on the first half of my statement before I come to respond to the questions that were posed to me directly by the Chairman Fuqua.

To summarize briefly, we at Hamilton Standard have been in the wind energy business a long time, longer than most and we know most of the pitfalls.

We have learned that you have got to have the basic technology in hand to design a successful, large system. We are the only ones that have it, the other guys do not and it is beginning to show.

We have learned that you cannot build a successful wind turbine by just assembling the other guy's components. That is why we assumed the role, 2 years ago, of system-designer/manager, with a total knowledge and control of all the interaction between components.

We at Hamilton Standard alone have had the confidence in our design to make the major investments and take the substantial financial risk required to assure a successful system. Our prototype machines are now nearing their final exams. They are best on paper and soon they will be best in fact.

Committing our own funds has assured us a substantial, independent, up front technological position, fully sufficient to meet the challenge of commercialization.

By the mid-1980's our machines should be competitive with oil and coal powered stations.

Mr. HARKIN. By when? 1986?

Mr. JACKSON. By the mid-1980's.

Utilities, however, will not buy machines until reliability is proven to their satisfaction.

The Department of Energy MOD-5 programs will not and cannot bridge this gap. For proof one only has to look at the MOD-1 and the MOD-2 programs and the results from them.

Despite their early promise, the effectiveness of all existing Federal incentives aimed to stimulate wind energy development are now eroding rapidly due to external economic forces. So, there is a problem on how to get there from here.

That, again, is a summary of about eight pages of statement. With your permission, however, I will now read from the balance of my statement which is intended to respond specifically and directly to the chairman's questions to me in the letter that I received on March 5.

The first question is: What do you see as the principal barriers to investments in these technologies? That is, of course, referring to renewable energies and, specifically, to the wind technology.

There remain today a number of barriers to investment in wind energy technology, the importance of each barrier being dependent upon the role of the business sector involved. For clarity, the perceived interests of each sector will be discussed individually. First, the electric utilities.

Electric utilities are clearly the only potentially significant users of the wind energy alternative, and only the large wind turbine systems, as study after study have shown, have a reasonable chance of making a measurable impact on the power production methods used to serve electricity demands in the years ahead. All barriers to utility usage of wind power are clearly economic in nature and, in decreasing order of importance, are as follows:

First, unproven equipment reliability.

Second, siting uncertainties, including environmental, which influence achievable levels of power production.

Third, excessive capital costs as measured in dollars per kilowatt hours.

Fourth, volatile oil prices.

For utilities with access to high energy intensive sites, which include many, if not most of those located in the Western United States, proof of equipment reliability and performance is the No. 1 roadblock to large wind turbine capital equipment programs.

None of the large, megawatt scale, wind turbine systems tested so far give reasonable confidence that reliability and performance levels necessary for large scale integration of wind turbines into a utility system's power production facility network are achievable.

The General Electric MOD-1, the Boeing MOD-2, the Bendix 3 MW, the Merkum 2 MW, the ALCOA ½ MW—none of these have come close to realizing the near troublefree operation necessary to promise commercial success.

Attempts in other countries so far have proven no better. All these machines have displayed serious technological deficiencies, and there is little evidence, at least publicly revealed, giving confidence that all known major problems will be resolved.

We strongly suspect that, in fact, none of the engineering design teams responsible for these prototypes have in hand the basic technology to solve these problems in any future designs.

In contrast, our WTS-3 in Sweden and our WTS-4 at Medicine Bow, we believe, have the inherent capability to demonstrate required performance and reliability, as we have effectively addressed and eliminated in our designs each known deficiency of the competition. But, of course, this remains to be proven, particularly to the satisfaction of potential user utilities, a process not likely to be rapid.

Even in the areas of generally high wind energy intensities, considerable uncertainties still exist as to the power production poten-

tial of environmentally acceptable wind farm sites. Frequently the annual wind energy profiles are insufficiently well-known to predict kilowatt power output for any specific machine with confidence.

Additionally, the complexities of environmental impact statements raise problems involving incurrence of substantial up-front project expenses prior to determination of the overall economic attraction of any given site. Until several wind park projects, involving a number of machines, have successfully reached the stage of commercial operation, such expenditures will be judged to be of excessively high risk and will discourage utility commitments to large projects.

For the many utilities that have potential access to the high energy intensive sites, projected specific capital costs in dollar per kilowatt hour, even for units produced in relatively low quantities, should not prove an impediment to major wind park developments. Manufacturers can meet capital cost goals required to attain competitive energy costs if reliability expectations are met.

Only in the low wind energy intensive sites do capital costs loom as a barrier of comparable weight and importance to the issue of reliability, but development of markets with such site dependence, in regions where the MOD-5 may have some economic potential, is, at best, far in the future.

Mr. HARKIN. Mr. Jackson, I am sorry I am going to have to interrupt you. This is going to take a long time and we are facing some time constraints. I think a lot of this will come out in the questions and answers and a lot of it we have read in your statement anyway.

Could you just, in a couple of minutes, take each question and summarize it. Just give me a summary of each question.

Mr. JACKSON. All right. I will skip along to the next one.

What Federal policies are needed to remove these barriers and encourage further development?

We feel that there is a potentially positive development with EPRI who represents the utilities seeing DOE back away now from developing and evolving wind energy coming in to take a stronger hand.

That involvement by the utilities should be encouraged by whatever means is appropriate shy of giving the utilities EPRI free machines, which, basically, is not a useful approach in our view.

To what degree can we rely on a decontrolled market to accelerate development of these technologies?

Obviously, where we stand today, the market is highly uncertain because of its relationship to oil prices as so many things are today but there is still, barring a total collapse over a long-term in oil price, we expect machinery based upon the technology that we have in hand to be competitive and to be an attractive product to utilities in the mid to late 1980's.

Has DOE's programs so far been successful in eliminating barriers?

We conclude that this, at best, is a real mixture. There has been some useful technology that has come out of the DOE program. We think that that amount of technology is quite limited. Obviously there have been a considerable amount of public attention that

has—and utility attention—that has resulted in DOE's involvement.

On the negative side, the program, so far, has been quite unsuccessful in attracting major private investment and with a continuation of the MOD–5 program we believe that that investment will be further delayed.

Finally, in answer to the last question I would like to read it in its entirety. It is relatively brief.

What do you anticipate will be the effects of terminating or significantly reducing DOE funding of these programs?

It should be obvious at this point that Hamilton Standard believes termination of DOE supported engineering development programs will have little negative and perhaps have a positive effect on the future commercialization of wind energy. We do support some modest increase in government-sponsored technology development.

Tax policy perhaps can be adjusted to be more effectively stimulative, potentially without added drain to the Federal treasury, although we do not wish to encourage abandonment of energy tax credits now in place.

Other than steps such as these, however, the Federals should step aside, leaving the private sector to have a relatively free hand to deal with future market forces.

Thank you.

[The prepared statement of Mr. Jackson follows:]

UNITED TECHNOLOGIES HAMILTON STANDARD

Windsor Locks, Connecticut 06096
203/623-1621

March 17, 1982

STATEMENT FOR HOUSE SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

Mr. Chairman and Members of the Committee:

My name is Art Jackson. I am Director of Wind Energy Systems at Hamilton Standard, a Division of United Technologies Corporation. We appreciate this opportunity to discuss our views regarding possible continued Federal Government support of Wind Energy development as related to the FY 1983 Department of Energy's budget authorization. Hamilton Standard has not been a contracting participant in the broad DOE/NASA Wind Energy program for several years. Our views, therefore, probably have a somewhat different perspective compared to those who have been more deeply involved with Federal Government development contracts, although perhaps not entirely at odds with them.

At the time I assumed the duties of managing Hamilton Standard's then rapidly expanding Wind Energy activity a year and a half ago, public support of this alternative energy was still very strong and a handful of major electric utilities were beginning to show more than a public relations interest in wind power development. We, for our part, had moved very near to consummating an agreement to construct and operate what was to be the first commercial multi-megawatt wind farm, and were prepared to invest substantially in the subsequent commercial development of wind power, meeting what we saw as the emerging needs of a growing number of utilities for economically viable power generation

alternatives in an era of continually increasing fossil fuel costs, There seemed to be an opportunity for explosive business growth just ahead.

Today the outlook has changed dramatically. Before addressing the difficult problems we now face in deciding our future path to a wind energy business, a brief review of the course we have pursued until now is appropriate.

Things started rolling at Hamilton Standard quite early. 1973 saw the initiation of our first in-house wind energy research activity in the post-war period with a small program involving aerodynamic analysis and test. During 1974 and 1975, our research expanded into system engineering studies, and into preliminary rotor system and blade designs. Most importantly, the development of wind turbine blade, rotor, and system analytical design tools was initiated at this time, a substantial effort that has been pursued without letup right up to the present. This work has had its roots in the unique, vast in-house background existing in the Corporation for describing mathematically the behavior of rotating machinery, using as a base those sophisticated techniques developed over many years to define accurately the dynamic structural behavior of Hamilton Standard's propeller systems and Sikorsky's helicopter rotor system.

I should pause here to point to the poor operating experience with large wind turbines constructed in recent years in this country and abroad, and thus how crucial our decision to develop these design tools was to our long term business outlook. This poor experience results directly from the fact that no satisfactory system dynamic analysis techniques have until recently existed for use in configuring the advanced, low cost, large 2-bladed wind turbine designs. Such tools are essential if one is to feel any reasonable degree of confidence that, without many years of prior operational experience on like system designs, the system components chosen will have acceptable useful lives. While, as a result of Hamilton Standard's continuous in-house research on the matter, this problem has been overcome

very successfully and the established technique applied in our designs, we see no evidence that this critical deficiency in engineering capability has been overcome elsewhere. Certainly, any future large wind turbines, no matter how new and innovative, but designed without benefit of methods of equivalent accuracy are likely to be seriously flawed structurally in ways not to become obvious until after hundreds, perhaps thousands, of operating hours.

By the late 1970's, analyses made clear to us that the design complexities of advanced wind turbine systems demanded the full integration of rotor and blade system designs with that of the overall wind turbine itself. This became a focus of our R&D work along with the specific attention we continued to direct to the one turbine component where established design and manufacturing techniques left a major technological void, that is, the rotor blade. Since Hamilton Standard had been generally unsuccessful in its bids to DOE/NASA for full-scale development of our design concepts, we turned to what became essentially a joint venture with a Swedish company (Swedyards--formerly Karlskronavarvet AB) to build and install a large 3-megawatt machine near Malmo for tests by Sweden's largest private utility, Sydkraft, under the auspices of the Swedish government. For this project, Hamilton Standard committed its advanced wind turbine system design capability and agreed to undertake the manufacture of the rotor blades whose unique design was based upon a filament wound, fiberglass construction technique. To meet this latter commitment, a whole new manufacturing facility had to be put in place. In turn, our Swedish associates provided a nacelle design, manufacture, and assembly capability, employing special engineering and manufacturing skills available within the large group of Swedish shipyard facilities,

which are generally known to be among the most technologically advanced in the world today.

Based upon design work performed to meet the requirements of the Swedish project, Hamilton Standard was the successful winner in a competition to provide a wind turbine System Verification Unit for the Department of Interior's Bureau of Reclamation for installation in Medicine Bow, Wyoming. The design selected by the BuRec evaluation team, assisted by NASA, was our 4-megawatt WTS-4. The resulting contract was undertaken at a Fixed Price and constituted essentially a commercial procurement by BuRec, one which funded little in the way of development costs, and placed considerable risks on us as prime contractor, thereby assuring much interest and attention by Hamilton Standard's top management.

A quick update on the status of these two prototype machines is as follows:

All components for both have been manufactured, assembled as subsystems, and subjected to exhaustive ground tests. The major subassemblies are, or are about to be, shipped to their respective sites. Finally, assembly and erection will take place late in the spring or in early summer, and first rotation in each instance is anticipated by mid-summer.

We are convinced that these two machines represent by far the most advanced state-of-the-art that exists in the world today. Their designs incorporate a number of unique features we believe are essential to commercial success, the feasibilities of which are backed by the advanced analytical design tools previously described, which have now reached a high level of development as measured in terms of the extraordinary engineering confidence now placed in them. We expect to

hit our target performance and prove anticipated system behavior this year, while avoiding the serious structural problems that have affected both major DOE/NASA Large Wind Turbine System projects. Our success in doing so will be known in a few months, but until this design substantiation is established to our satisfaction, a major commitment to production of these machines would involve unacceptably high risks for us, as, we suppose, a similar commitment would for any serious manufacturer of a large system who lacks equivalent substantiation.

It is appropriate to note here that subsequent to some early DOE/NASA contracted activities, the last of which ended about 5 years ago, the costs of our R&D work have been borne for the most part by Hamilton Standard and its Swedish associate. The effort involved has been considerable, amounting to approximately $25M investment just for us. The expense to our Swedish partner has also been large. Taken together, our two companies have provided financial support that far exceeds the total funding received from our two government agencies. These investments have not been without certain important side benefits, particularly in the areas of know-how and patents where we have been able to retain ownership rights. These rights, we are sure, will be of some considerable value to us in years ahead, if the wind energy business develops as anticipated.

The primary objective and justification of our investment, of course, was to put in place all the technology necessary for the early commercializtion of wind energy and to establish a lead position in the race to commercialize which only a year ago seemed on the threshold of developing. Our success can only be measured by the potential value of our equipment in such an emerging commercial market environment, and we believe that such measurement will show we have done our work well. Results of current

in-house analysis of anticipated equipment costs and turbine performance point to wind turbine produced electricity at costs, when levelized in accordance with standard utility practices, competitive by the mid-1980's with fossil fuel alternatives, even if real fuel prices, either oil or coal, do not increase over the long term at more than underlying inflation rates. Such wind energy costs are not significantly dependent upon high volume rates of wind turbine production. We see capital equipment cost goals for utility owned power stations that produce power competitively with conventional fossil fuel alternatives to be both reasonable and realistically achievable with WTS-4 derivative equipment. All the foregoing is based on the assumption that all technological barriers have been resolved. We are convinced we have done so. Others have not.

So, where is the problem? The answer is simple. Utilities themselves are not yet ready to buy hardware, whatever the price, largely because the reliability and performance of the equipment is unproven. Considerable additional expenditures must be made if this fundamental barrier is to be overcome, and needed funds will undoubtedly have to originate largely from sources other than directly from individual utilities. Note, Mr. Chairman, that current government programs funding development of MOD-5 machines are unlikely to address, let alone resolve, this problem, since even if these machines are built and tested as planned, the conclusions reached regarding potential machine performance, reliability, and operating costs are unlikely to be any less superficial than those resulting from the MOD-1 and MOD-2 programs. Possible contractor cost participation, a risk sharing breakthrough by DOE if achieved, would by no means automatically assure a different outcome.

Having raised the matter of the MOD-5, it is useful to recall the period of my last testimony on the wind energy subject to the House

Committee on Science and Technology, that is, the fall of 1979, when hearings were being held on Bill HR 3558, subsequently to become the National Wind Energy Act of 1980. First, let me say that we at Hamilton Standard and United Technologies Corporation at that time strongly supported this Act whose aim was to sponsor a number of carefully drawn initiatives. Among these was to be funding both for the MOD-5 programs, a contract for which we subsequently submitted an unsuccessful bid, and for construction of a large quantity of production machines for operational evaluation by utilities in many sections of the country. Even at that time, we felt that of the various elements of the proposed legislation, this latter initiative had by far the greatest potential for moving the wind energy business forward at a pace sufficient to meet, in those days of the second oil price shock, what seemed to be a National need. This was the time also of arrival on the scene of other important federally-inspired alternative energy development incentives, including the key PURPA legislation which allowed the formation of unregulated Small Power Producer companies, and special energy tax legislation which had the potential for attracting very substantial amounts of capital from the private investment sector to wind energy projects.

We quickly came to realize that these latter legislative moves had very large potential for stimulating development of wind energy independent of the direct government financial assistance promised by the Wind Energy Act, likely, in fact, to be much more stimulative if oil prices continued to rise rapidly as was then generally forecasted. Several entrepreneurial Small Power Producer companies were quickly formed, some of which approached us with serious proposals to put in operation privately financed, multi-unit groups of large multi-megawatt machines. The most interesting and solidly based of these proposals

95-882 O—82——31

was the so-called Kahuku Point Project, conceived and undertaken by Windfarms Ltd., an innovative Small Power Producer company, headquartered in San Francisco. As negotiations proceeded, it became apparent, however, that even with escalating fuel oil prices, because of the "technological risk factor", successful financing of this project would have to be based on substantial guarantees and financial underwriting by the contractors involved. After much hard bargaining, agreement in principle was reached with Windfarms on a project scope and associated financing approach which committed Hamilton Standard and its parent, UTC, to substantial investment and risk share.

Unfortunately, even this aggressive financing concept proved insufficient to sustain the project against rapidly changing external economic forces. The combination of increasingly high interest rates, which was destructive to project cash flow, and flattening oil price increase projections, which destroyed the expectations of potential outside investors, made timely financing unachievable, and necessitated dissolution of the agreement we had worked so hard to achieve. Thus, the major opportunity to prove expected levels of machine reliability under the hard, commercially realistic conditions of a broadly-based private investment environment was lost.

So far, other means to accomplish the goals of this particular project have not been successfully put in place. Learning from this experience, however, and observing the trials of the many others who are earnestly endeavoring to create, through wind power, a new economically viable type of capital asset, have taught us many things that are useful in attempting to answer the questions you, Mr. Chairman, posed in your letter to me dated March 5, 1982. I will now attempt to address each of these.

What do you see as the principal barriers to investments in these technologies?

There remain today a number of barriers to investment in the wind energy technology, the importance of each barrier varying dependent upon the role of the business sector involved. For clarity, the perceived interests of each sector will be discussed individually.

Electric Utilities

Electric utilities are clearly the only potentially significant users of the wind energy alternative, and only the large wind turbine systems, as study after study have shown, have a reasonable chance of making a measurable impact on the power production methods used to serve electricity demand in the years ahead. All barriers to utility usage of wind power are clearly economic in nature and, in decreasing order of importance, are:

(a) Unproven equipment reliability.
(b) Siting uncertainties, including environmental, which influence achievable levels of power production.
(c) Excessive capital costs ($/Kwhr).
(d) Volatile oil prices.

For utilities with access to high energy intensive sites, which include many, if not most of those located in the western U.S., proof of equipment reliability/performance is the number one roadblock to large wind turbine capital equipment programs. None of the large, megawatt scale, wind turbine systems tested so far give reasonable confidence that reliability and performance levels necessary for large scale integration of wind turbines into a utility system's power production facility network are achievable. The GE MOD-1, the Boeing MOD-2, the Bendix 3 MW, the Merkum 2 MW, the ALCOA 1/2 MW — none of these have come close to realizing the near troublefree operation necessary to promise commercial success. Attempts in other countries

so far have proven no better. All these machines have displayed serious technological deficiencies, and there is little evidence, at least publicly revealed, giving confidence that all known major problems will be resolved. We strongly suspect that, in fact, none of the engineering design teams responsible for these prototypes have in hand the basic technology to solve these problems in any future designs. In contrast, our WTS-3 (Sweden) and WTS-4 (Medicine Bow), we believe, have the inherent capability to demonstrate required performance and reliability, as we have effectively addressed and eliminated in our designs each known deficiency of the competition. But, of course, this, too, remains to be proven, particularly to the satisfaction of potential user utilities, a process not likely to be rapid.

Even in areas of generally high wind energy intensities, considerable uncertainties still exist as to the power production potential of environmentally acceptable wind farm sites. Frequently, the annual wind energy profiles are insufficiently well known to predict Kwhr output for any specific machine with confidence. Additionally, the complexities of environmental impact statements raise problems involving incurrence of substantial up-front project expenses prior to determination of the overall economic attraction of any given site. Until several wind park projects have successfully reached the stage of commercial operation, such expenditures will be judged to be of excessively high risk and will discourage utility commitments to large projects.

For the many utilities that have potential access to the high energy intensive sites, projected specific costs ($/Kwhr) of capital equipment, even for units produced in relatively low quantities, should not prove an impediment to major wind park developments. Manufacturers can meet

capital cost goals required to attain competitive energy costs, if reliability expectations are met. Only in low wind energy intensive sites do capital costs loom as a barrier of comparable weight to the issue of reliability, but development of markets with such site dependence, in regions where the MOD-5 may have some economic potential, is, at best, far in the future.

In the above discussion, the annual fluctuations in oil price are assumed to be of somewhat secondary importance to the plans of many, if not most, utilities since conventional wisdom these days supports those long term plans that promise lessened dependence on oil and natural gas for future power generation. Obviously, a major collapse in oil price over an extended period could obsolete such judgements.

Small Power Producers

For Small Power Producers, investment plans must deal first with predicting the future direction of oil price, an almost impossible task in today's world. After the oil price issue, also in descending order of importance, come the problems of high interest rates, obtaining adequate equipment manufacturers' guarantees, assuring the continued availability of energy tax credits, and finally, obtaining specific capital cost commitments ($/Kwhr) which, after all the above variables have been tied down, may trim a project's financability into "doable" form.

The volatility in oil price has, for the present, essentially destroyed the ability of Small Power Producers to assemble large amounts of outside investment capital in states other than California where the extra energy tax credit available thru 1983 almost makes it unnecessary for wind turbines to produce any power at all. In addition, current

high interest rates, if continued, particularly if coupled with collapsing oil prices, practically make it impossible to maintain adequately positive project cash flows, while at the same time providing even minimal debt service. Because of the "technological risk factor" associated with unproven equipment, manufacturers' guarantees are required to obtain outside credit, and are now available only to a limited degree.

Also essential to continued existence of most Small Power Producers are the existing Energy Tax Credits. To the broader public interest, however, these are a mixed blessing. Because of their current legislated time limits and susceptibility to legislative change, these credits tend to encourage flow of what limited investment funds may still be found to equipment manufacturers who can provide a product quickly but with, in most instances, little proof, even on paper, of long term equipment reliability. Such situations, obviously, may not serve the long range needs of the utility industry and the public it serves, as many of the projects so formulated will crash when design faults eventually show up in actual operation.

Finally, too high a specific capital cost does adversely affect the economics of any given project, but federal tax benefits now available tend to reduce the significance of this factor, in all but the most financially marginal of projects.

Manufacturers

Of all manufacturers, Hamilton Standard, we are sure, has accumulated the greatest investment stake in wind energy in terms of both R&D accomplished and manufacturing facilities put in place. We anticipate now a greatly reduced rate of growth in this investment

until commitments can be obtained from substantial buyers of either machines or of power our machines can produce. We believe that such commitments, even in today's climate, still can be obtained, but not with the ease previously assumed. As for other manufacturers of large machines, who have yet to take much investment risk, we can only presume they have little to lose by a passive approach to market development.

What Federal policies are needed to remove these barriers and encourage further development?

Obviously, Hamilton Standard will favor any effective Federal policies to eliminate or lessen the economic barriers which now impede the acceptance and use of cost effective wind energy by the utility industry. In our view, the only area where steps now taken by the Federal Government can provide real long term benefits involves encouragement of utilities to take positive action themselves, a difficult task even without the added burden of today's economic downturn. Direct funding of manufacturers for the development of new engineering prototypes without major utility participation does nothing useful in this regard, and probably at this point has a detrimental effect on developing a broadly-based utility involvement in wind energy generally, as it purports to attack what we believe is the least important barrier, that is, specific capital cost, and it tends to put off the coming to grips with the key issues (machine reliability, etc.) which must be overcome to meet the economic challenge successfully. We wish to point out again that needed machine reliability can never be realized if new engineering designs continue to be formulated on an inadequate technology foundation, a basic situation widespread today.

We view as a hopeful sign the evidence that the Electric Power Research Institute, seeing DOE stepping back from its involvement in wind energy, may come forward to pick up the slack in critical areas. EPRI has the means to represent true utility industry interests, and clearly would not ignore, or slant the economic realities of this difficult task. In our opinion, a more effective Government effort than continued direct sponsorship of engineering R&D would be a subsidy provided to EPRI for their use in realistic evaluation and improvement of existing equipment against realistic utility industry requirements. For EPRI to take on such a role is easy to describe but, of course, hard to implement. We suspect that, even if substantial funds could be appropriated for this purpose, EPRI would not be particularly interested in such government handouts with the attached strings which would be expected. We feel such an EPRI managed effort would more likely be accepted through a tax policy which would incentivize private utilities to invest in EPRI wind projects. Such an approach would probably benefit wind energy development more directly than the indiscriminate distribution of energy tax credits, as these latter are generally hit-or-miss in effectiveness, as earlier described.

Although supporting its withdrawl from direct involvement in engineering development, we encourage continuance of moderate Federal support of basic technology efforts which will serve industry interest generally. NASA has built a very competent in-house capability to carry on such a program, and it would be a sad waste of a laboriously built public asset to disband it. Technologically, the engineering of wind turbines is much more complex than is generally recognized, and a neutral government base for technology development will continue to be a good investment of public funds. The support of such activity at NASA envisioned in the 1983 Draft Legislation, we believe, should be maintained and possibly expanded in the area of research into strength of key wind turbine components. Since we have in hand at Hamilton Standard, however, validated, full system "structural dynamic" analysis tools, the proposed expenditure to repeat this technology development would be both wasteful and a direct subsidy of our competition. Let our competitors, who are the only parties to benefit, satisfy their own needs in this regard at their own expense.

To what degree can we rely on a decontrolled market to accelerate development of these technologies?

Current market forces have substantially increased the risks of continued investments in wind energy, but so have they for most high technology product developments. While recognizing the resulting slowing of all activity now under way in this field, in our view, industry is still the best capable of dealing with these market forces without the heavy hand and distorting effects of direct government subsidy.

How successful have DOE programs been in aiding development and overcoming market barriers?

The answer to this question is "A Mixed Bag". The DOE program, on the one hand, has caused the development of some useful technology. Additionally, the magnitude of the projects involved has drawn positive public attention and stimulated utility interest, continuance of which is important to the business outlook. The results to date from the Large Wind Turbine engineering development projects, however, have been much less than satisfactory, considering the magnitude of the government investments made. Too many technical issues remain unresolved, largely we think, because of the unwillingness of the involved Private Sector to make more than token business commitments. In our judgement, there is no good reason to believe that follow-on endeavors, similarly sponsored, will achieve any greater benefits.

What do you anticipate will be the effects of terminating or significantly reducing DOE funding of these programs?

It should be obvious at this point that Hamilton Standard believes termination of DOE supported engineering development programs will have little negative and perhaps have a positive effect on the future commercialization of wind energy. We do support some modest increase in government-sponsored technology development. Tax policy perhaps can be adjusted to be more effectively stimulative, potentially without added drain on the Federal treasury, although we do not wish to encourage abandonment of energy tax credits now in place. Other than steps such as these, however, the Federals should step aside, leaving the Private Sector to have a relatively free hand to deal with future market forces.

Thank you, Mr. Chairman.

Mr. HARKIN. Thank you very much, Mr. Jackson.

Mr. DiGiovacchino? We will make your written testimony a part of the record.

STATEMENT OF DAN DiGIOVACCHINO, MANAGER, WIND ENERGY PROGRAMS, GENERAL ELECTRIC CO.

Mr. DiGIOVACCHINO. Thank you, Mr. Chairman.

My name is Dan DiGiovacchino. I am the manager of Wind Energy Programs for General Electric.

We appreciate this opportunity to present to you the status of our wind energy activities. We have a few slides and I have cut a lot out of the testimony.

Through its involvement in a number of alternate energy programs, the General Electric Co. has evaluated the various solar options and has concluded that wind energy will be among the first to become economically viable for utility application. Figure 1 summarizes the cost projections for several of the leading solar options where the curves indicate program goals. Our MOD-5A studies to date indicate that we may beat these goals.

We have previously concluded that a substantial wind resource exists in this country which, if fully developed, could contribute in excess of 5 quads to the Nation's energy supply. Figure 2 shows the locations of the important wind resources which are concentrated in seven major areas. In Addition, localized, potentially economic sites exist in many other areas of the country. The economics projects for the MOD-5A machine should permit the development of this resource into a substantial market.

Figure 3 summarizes the development of the major wind resources and you can see that, indeed, this does represent a substantial market.

Since its inception in 1974, the Federal wind energy program has achieved good results. As indicated in figure 4, with the machines shown approximately to scale, the technology has developed from early experimental and inefficient designs to partial span tip control, teetered rotors, and lighweight, compliant towers of very large machines. The significant characteristics of succeeding generations of designs are displayed in figure 5. The energy ratings have progressed from a few hundred kilowatts to multi-megawatts and the sizes have grown from 125 foot diameter rotors to 400 foot diameter rotors, on 250 foot towers.

Even more dramatic is the improvement of projected energy costs which have been reduced from very high, non-competitive figures to less than 5 cents per kilowatt-hour cost of energy in today's dollars. The General Electric MOD-5A is a culmination of this effort and one of the first machines with projected economics suitable for utility applications.

The MOO-5A program is well underway and remains on schedule and within budget, consistent with the funding restraints placed upon the program. Figure 6 summarizes the current schedule milestones and status. The conceptual design was completed in March of 1981 and the preliminary design phase in which complete integration of the design is accomplished, will be completed in April of this year.

This design process has been complemented throughout by an extensive internal and external review activity bringing to bear the expertise of both Government agencies and General Electric to assess and, as necessary, to modify the design. This process has resulted in a design which not only incorporates significant technological advances but also appropriate commercial features which are responsive to the customer requirements.

As shown in figure 7, the key technological advances of the MOD–5A include a substantial step-up in size, rating and energy capture; the utilization of a weight-efficient, laminated wood-epoxy blade; the capability to operate at two different speeds in order to accommodate seasonal and other variations of wind profile; simplified control systems for controlling rotor speed and wind orientation; and a unique weathervane approach for reducing peak loads under severe wind conditions.

These design advances are not without risk however and much of the development work remains to be done to assure the reliable, high availability type of performance which this product must exhibit for power system applications. Figure 8 identifies the major technological risks associated with the development and the actions planned.

In the past year, there has been a shift in emphasis of the Federal alternate energy program. The private sector is being called upon to accept greater responsibility for alternate energy development. Federal activities are being adjusted to focus on long-term, high-risk, high-payoff research and development. In this committee's Authorization Report for 1982, NASA/DOE were requested to seek cost-sharing by the MOD–5 contractors for completion of the development program. In turn, NASA/DOE requested that the existing MOD–5 development contracts be modified to include substantial cost-sharing.

We, at General Electric, have concluded that participation in a cost-sharing arrangement with NASA/DOE for the completion of the MOD–5A development is the most responsible and responsive option for us. We are currently engaged in detailed discussions with NASA to define such an arrangement. To date we have found that we are in substantial agreement and we expect to conclude an agreement acceptable to both parties, in the very near future.

We believe that the MOD–5A will achieve its economical cost and performance goals. The cost projections have been examined from a bottoms-up cost analysis approach and from a comparison with related technology and developments. Figure 9 demonstrates that the MOD–5A projection is consistent with the actual experience of other forms of generation equipment and that the cost of the mature product is comparable to the cost of other equipment of similar size and complexity.

We at General Electric believe that wind energy can make a meaningful contribution to the Nation's energy supply and that the MOD–5A is a machine with projected characteristics and economics which can help achieve this promise. The MOD–5A program is the logical conclusion of the Federal large wind energy program with a well-defined plan and a completion which is clearly in sight. The satisfactory completion of the MOD–5A could lead to a new industry, creating domestic jobs while displacing foreign oil

and at the same time protecting our technological lead against the threat of increased foreign competition in yet another arena.

Thank you, Mr. Chairman.

[The prepared statement of Mr. DiGiovacchino follows:]

TESTIMONY PRESENTED BY

D. J. DIGIOVACCHINO, MANAGER

WIND TURBINE PROGRAMS

GENERAL ELECTRIC COMPANY

Through its involvement in a number of alternate energy programs, the General Electric Company has evaluated the various solar options and has concluded that wind energy will be among the first to become economically viable for utility application. Figure 1 summarizes the cost projections for several of the leading solar options where the curves indicate program goals. The results of our MOD-5A trade studies indicate that we may beat these goals.

We have previously concluded that a substantial wind resource exists in this country which if fully developed, could contribute in excess of 5 quads to the nation's energy supply. Figure 2 depicts the location of the important wind resources which are concentrated in seven major areas. There are, in addition, localized, potentially economic sites in many other areas of the country. The economics projected for the MOD-5A machine should permit the development of this resource into a substantial market. Figure 3 summarizes the development potential of the major wind resource areas.

Since its inception in 1974, the federal wind energy program has achieved good results. As indicated in Figure 4, the technology has developed from early experimental and inefficient designs, such as full blade pitch control and heavy steel truss-type towers, to partial span tip control, teetered rotors, and lightweight, compliant towers. The significant characteristics of succeeding generations of designs are displayed in Figure 5. The energy ratings have progressed from a few hundred kilowatts to multi-megawatts and the sizes have grown from 125 ft diameter rotors to 400 ft diameter, on 250 ft towers. Even more dramatic is the improvement of projected energy costs which have been reduced from very high non-competitive figures to $< 5¢/KWH$ cost of energy (COE), in today's dollars. The General Electric MOD-5A is a culmination of this effort and one of the first machines with projected economics suitable for utility applications.

The MOD-5A program is well underway and remains on schedule and within budget, consistent with the funding restraints placed upon the program. Figure 6

summarizes the current schedule milestones and status. The conceptual design phase, in which many major trade studies were performed and the basic concept selected, was completed in March 1981. The preliminary design phase in which complete integration of the design is accomplished, will be completed in April of this year, at which time the final design phase is scheduled to commence and the detailed manufacturing drawings will be produced.

The design process has been complemented throughout by an extensive internal and external review activity bringing to bear the expertise of both government agencies and General Electric to assess and, as necessary, to modify the design. We have carefully reviewed and integrated potential customer requirements into the design process through the establishment of a User Review Board composed of senior representatives of the major potential wind turbine utility customers. This process has resulted in a design which not only incorporates significant technological advances but also appropriate commercial features responsive to customer requirements.

Figure 7 summarizes the key technological advances of the MOD-5A design. Among the most important features and innovations of MOD-5A are: a substantial step-up in size, rating and energy capture; the utilization of a weight-efficient, laminated wood-epoxy blade; the capability to operate at two different speeds in order to accommodate seasonal and other variations of wind profile; simplified control systems for controlling rotor speed and wind orientations; and a unique weathervane approach for reducing peak loads under severe wind conditions.

These design advances are not without technological risk, however, and much development work remains to be done to assure the reliable, high availability type of performance which this product must exhibit for power system applications. Figure 8 identifies the major technological risks associated with the development and the actions planned. The wood-epoxy blades are the largest structure of this type ever attempted and utilize a material whose properties must be verified for this long life, high fatigue application.

The large size of the blades further necessitates that a joint be developed which can be reliably assembled in the field since the full blade is unshippable by conventional transportation. A completely reliable means must be developed and proven for attaching the steel structure of the blade tip control mechanism to the wood-epoxy structure of the blades. This joint must withstand continuous operation under high load conditions. The torque levels that have to be accommodated at the low speed end of the gearbox stretches the manufacturing capabilities of even the largest gear manufacturers in this country and the drive system dynamics can only be determined after the prototype has been built and tested.

In the past year, there has been a shift in emphasis of the federal alternate energy program. The private sector is being called upon to accept greater responsibility for alternate energy development. Federal activities are being adjusted to focus on long term, high-risk/high-payoff research and development. In this Committee's Authorization Report for 1982, NASA/DOE were requested to seek cost sharing by the MOD-5 contractors for completion of the development program. In turn NASA/DOE requested that the existing MOD-5A development contract be modified to include substantial cost sharing. Having examined a number of alternatives for responding positively to the new focus in the federal energy program, we at GE have concluded that participation in a cost sharing arrangement with NASA/DOE for the completion of the MOD-5A development is the most responsible and responsive option for us. We are currently engaged in detailed discussions with NASA to define such an arrangement with suitable terms and conditions. To date, we have found that we are in substantial agreement and we expect to conclude an agreement acceptable to both parties, in the very near future.

We believe that the MOD-5A will achieve its economical cost and performance goals. The cost projections have been examined from both a detailed, bottoms-up cost analysis approach and from a comparison with related technology and developments. Figure 9 demonstrates that the MOD-5A projection is consistent

with the actual experience of other forms of generation equipment and that the cost of the mature product is comparable to the cost of other equipment of similar size and complexity. This substantiation of our projection of costs, coupled with our analysis of the revenue producing value of the MOD-5A in areas of good wind resource, leads us to believe that a substantial market should develop for the MOD-5A wind turbine.

We at General Electric believe that wind energy can make a meaningful contribution to the nation's energy supply and that the MOD-5A is a machine, with projected characteristics and economics, which can help achieve this promise. The MOD-5A program is the logical conclusion of the federal large wind energy program with a well defined plan and a completion which is clearly in sight. The satisfactory completion of the MOD-5A could lead to a new industry, creating domestic jobs while displacing foreign oil and at the same time protecting our technological lead against the threat of increased foreign competition in yet another arena.

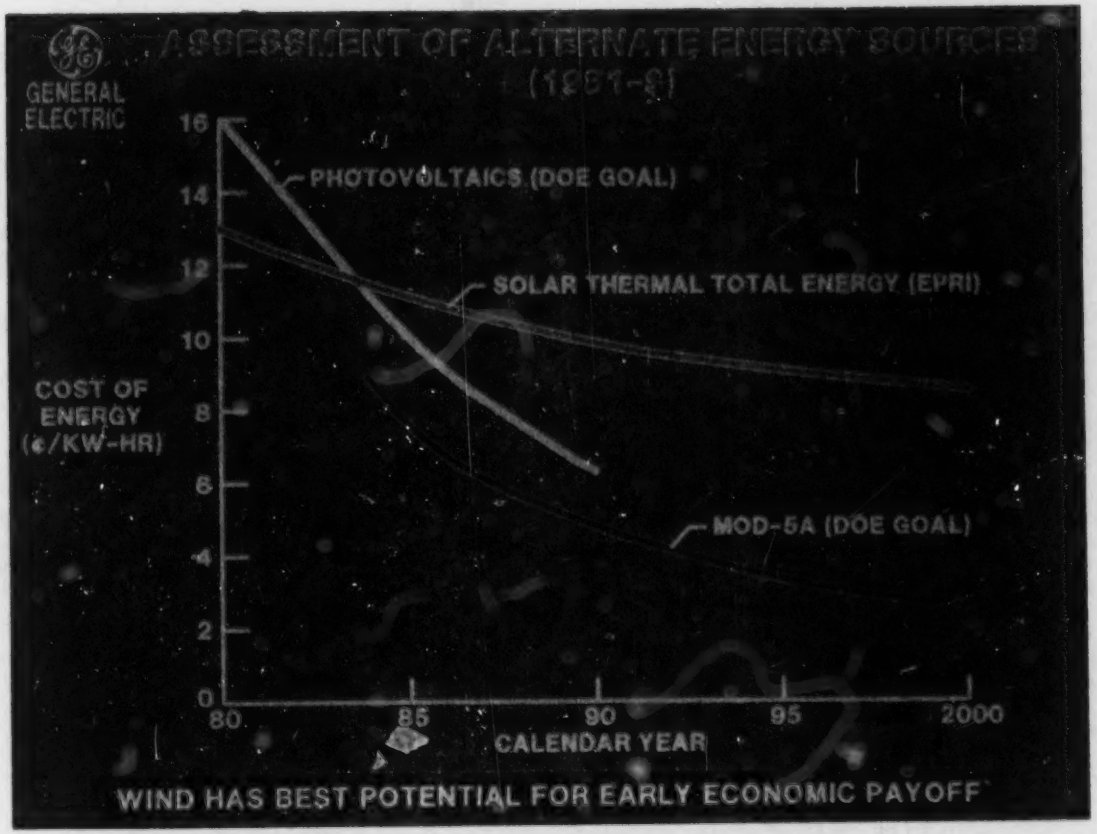


FIGURE 1.

95-882 O—82——32

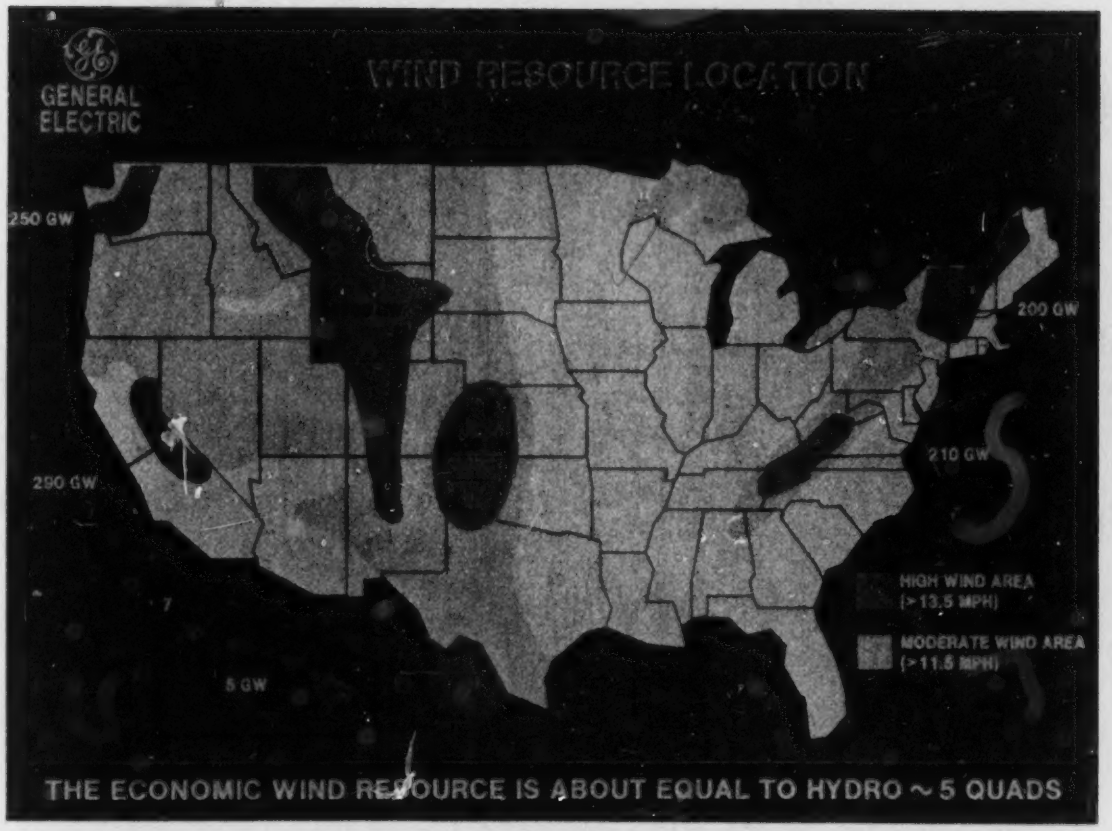

GENERAL ELECTRIC
WIND RESOURCE LOCATION
250 GW
200 GW
210 GW
290 GW
5 GW
HIGH WIND AREA (> 13.5 MPH)
MODERATE WIND AREA (> 11.5 MPH)
THE ECONOMIC WIND RESOURCE IS ABOUT EQUAL TO HYDRO ~ 5 QUADS

FIGURE 2.

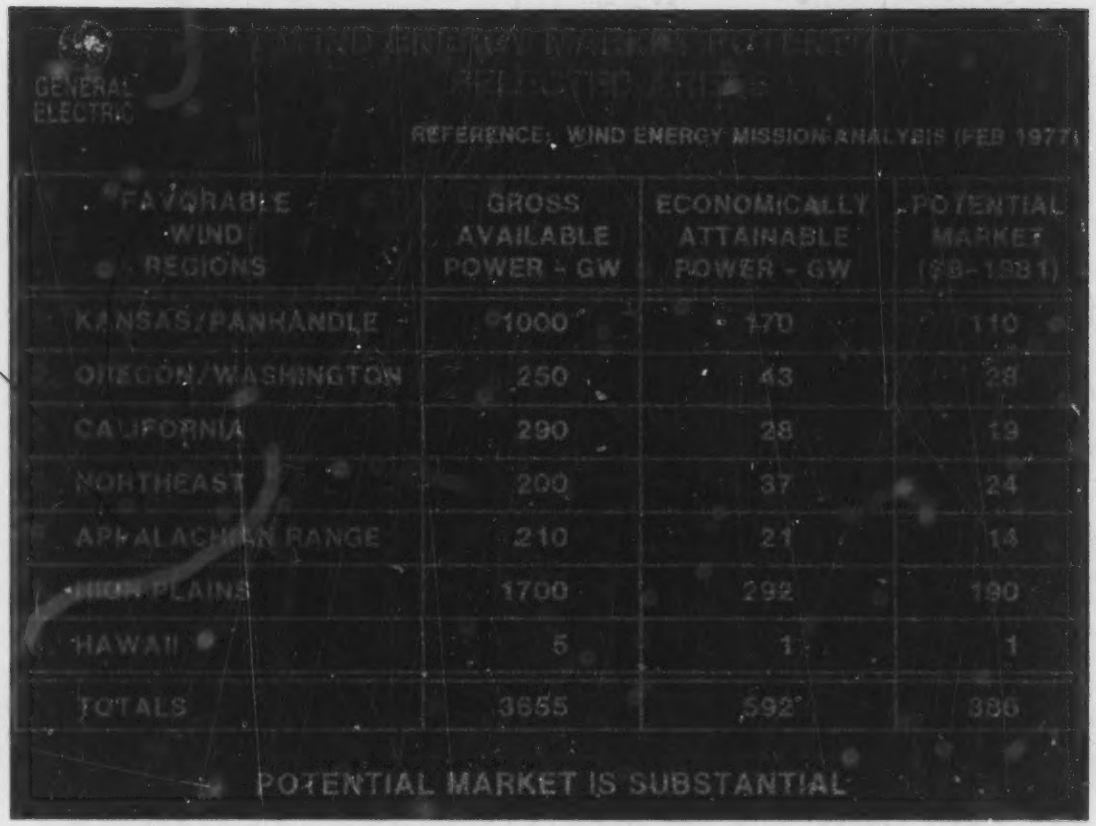

GENERAL ELECTRIC
REFERENCE: WIND ENERGY MISSION ANALYSIS (FEB 1977)
FAVORABLE WIND REGIONS
GROSS AVAILABLE POWER - GW
ECONOMICALLY ATTAINABLE POWER - GW
POTENTIAL MARKET ($B-1981)
KANSAS/PANHANDLE 1000 170 110
OREGON/WASHINGTON 250 43 28
CALIFORNIA 290 28 19
NORTHEAST 200 37 24
APPALACHIAN RANGE 210 21 14
PLAINS 1700 292 190
HAWAII 5 1 1
TOTALS 3655 592 386
POTENTIAL MARKET IS SUBSTANTIAL

FIGURE 3.

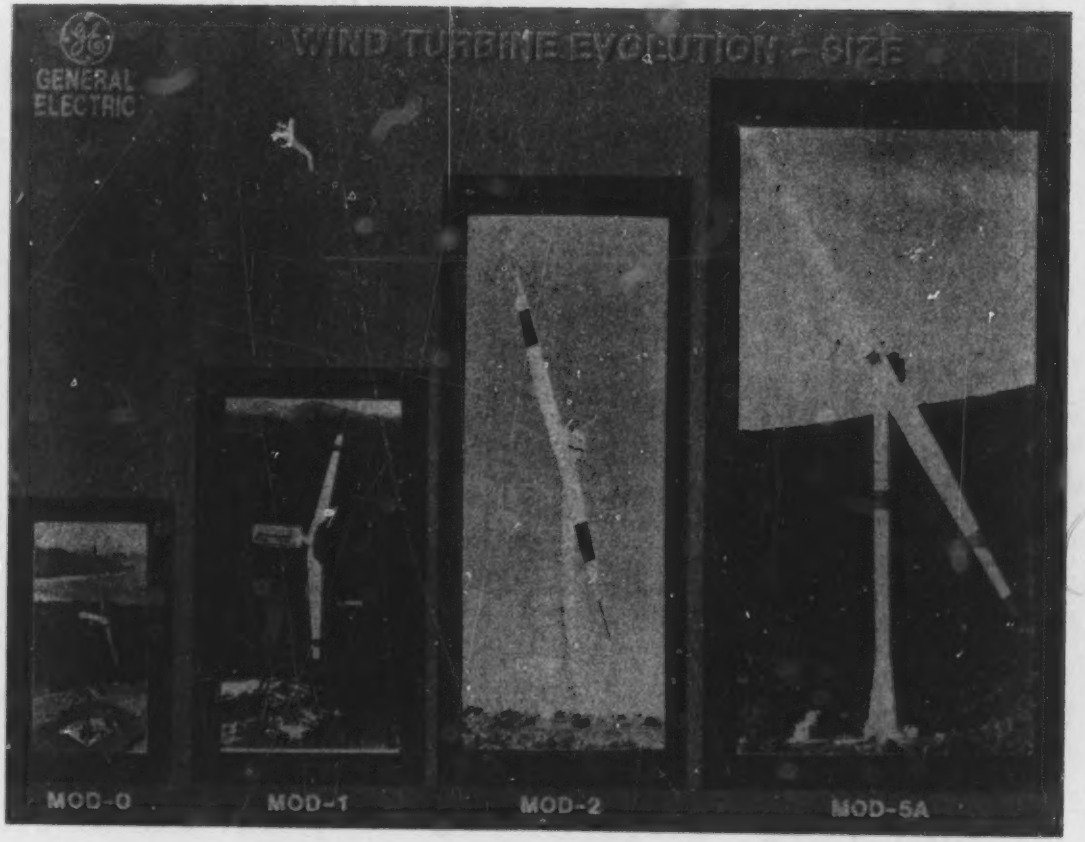

GENERAL ELECTRIC
WIND TURBINE EVOLUTION - SIZE
MOD-0
MOD-1
MOD-2
MOD-5A

FIGURE 4.

GENERAL ELECTRIC

EVOLUTION OF THE UTILITY CLASS WIND TURBINE

DATA \ MACHINE	1ST GENERATION MOD - 0/0A 1975	1ST GENERATION MOD - 1 1979	2ND GENERATION MOD - 2 1981	3RD GENERATION MOD - 5A 1984
POWER RATING - KW_e	100/200	2000	2500	6200
ROTOR DIAMETER - FT	125	200	300	400
ANNUAL ENERGY CAPTURE (GWH/YR - 14 MPH)	.65	6.3	8.7	21.6
SPECIFIC POWER - LB/KW_e	800	328	240	200
COST OF ENERGY (¢KWH - 1981)				
a) 1ST UNIT	>50	20.5	13.4	7.0 - 9.8
b) 100TH UNIT	- -	- -	7.3	3.4 - 4.7

SIGNIFICANT TECHNOLOGICAL ADVANCES HAVE LED TO ATTRACTIVE 3RD GENERATION ECONOMICS

FIGURE 5.

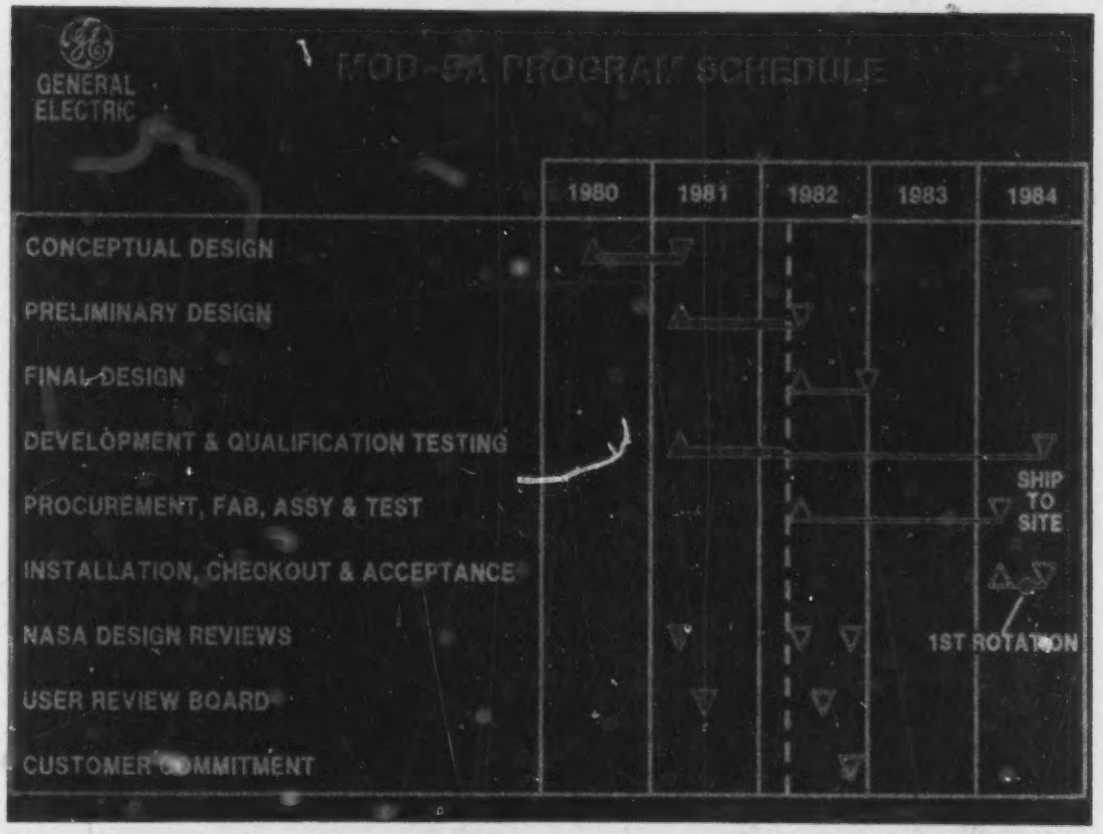

GENERAL ELECTRIC
MOD-5A PROGRAM SCHEDULE
1980
1981
1982
1983
1984
CONCEPTUAL DESIGN
PRELIMINARY DESIGN
FINAL DESIGN
DEVELOPMENT & QUALIFICATION TESTING
PROCUREMENT, FAB, ASSY & TEST
SHIP TO SITE
INSTALLATION, CHECKOUT & ACCEPTANCE
NASA DESIGN REVIEWS
1ST ROTATION
USER REVIEW BOARD
CUSTOMER COMMITMENT

FIGURE 6.

GENERAL ELECTRIC

FEATURE	MAJOR BENEFIT
SIGNIFICANT SCALE-UP FROM PRESENT TECHNOLOGY	LARGE REDUCTION IN COE LESS LAND INTENSIVE, MORE EFFICIENT FOR OPERATION & MAINTENANCE
WEATHER VANE ROTOR ASSY WOOD LAMINATE BLADES (MULTIMEGAWATT APPLICATION) HIGH EFFICIENCY ROTOR AIRFOIL SECTION	REDUCE HURRICANE LOADS BY FACTOR OF TWO REDUCES SYSTEM COST AND WEIGHT IMPROVES ENERGY CAPTURE
HYBRID EPICYCLIC/PARALLEL SHAFT DESIGN INTEGRAL ROTOR BEARING ARRANGEMENT	HIGH TORQUE CAPABILITY AT INPUT, LOW COST AT HIGH SPEED END SIGNIFICANT REDUCTION IN MOMENTS ON NACELLE SUPPORTS, REDUCED BEDPLATE WEIGHT AND COST
PUSH-PULL HYDRAULIC SYSTEM	PROVIDES ACTIVE YAW CONTROL AT LOW COST WITH HIGH RELIABILITY

FIGURE 7.

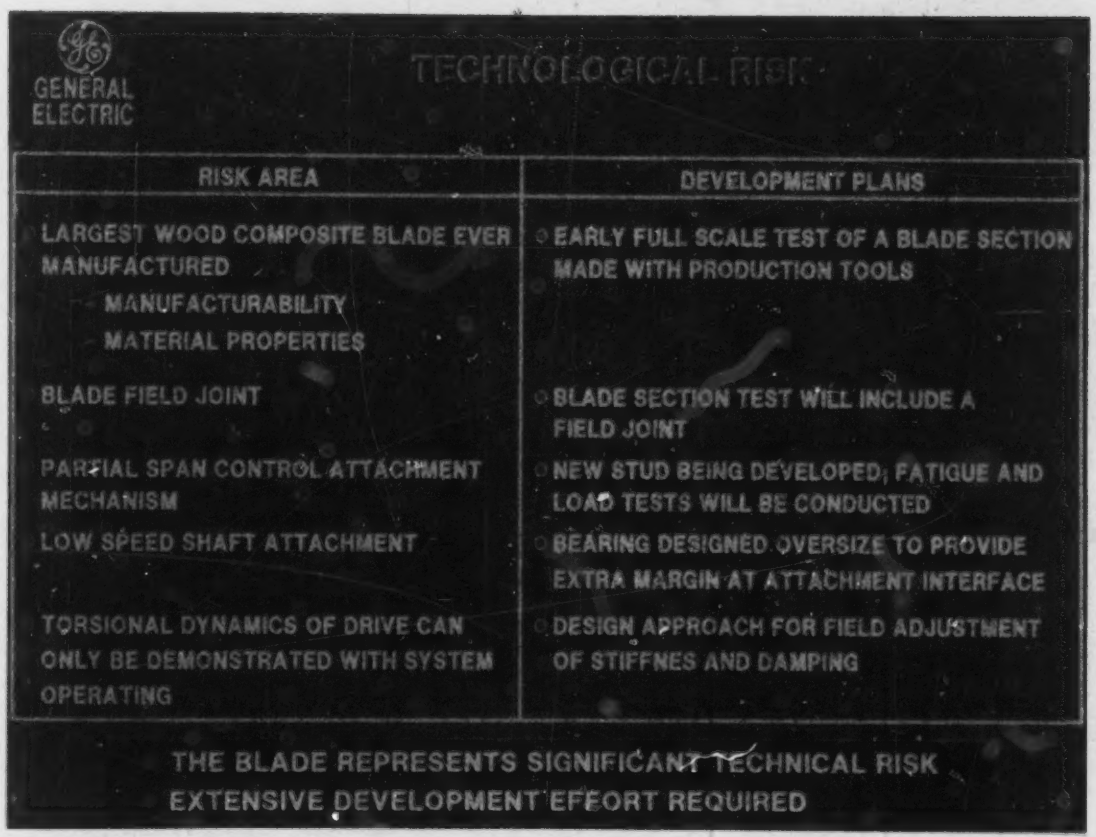

GENERAL ELECTRIC
TECHNOLOGICAL RISK
RISK AREA
DEVELOPMENT PLANS
LARGEST WOOD COMPOSITE BLADE EVER MANUFACTURED
- MANUFACTURABILITY
- MATERIAL PROPERTIES
EARLY FULL SCALE TEST OF A BLADE SECTION MADE WITH PRODUCTION TOOLS
BLADE FIELD JOINT
BLADE SECTION TEST WILL INCLUDE A FIELD JOINT
PARTIAL SPAN CONTROL ATTACHMENT MECHANISM
NEW STUD BEING DEVELOPED; FATIGUE AND LOAD TESTS WILL BE CONDUCTED
LOW SPEED SHAFT ATTACHMENT
BEARING DESIGNED OVERSIZE TO PROVIDE EXTRA MARGIN AT ATTACHMENT INTERFACE
TORSIONAL DYNAMICS OF DRIVE CAN ONLY BE DEMONSTRATED WITH SYSTEM OPERATING
DESIGN APPROACH FOR FIELD ADJUSTMENT OF STIFFNES AND DAMPING
THE BLADE REPRESENTS SIGNIFICANT TECHNICAL RISK
EXTENSIVE DEVELOPMENT EFFORT REQUIRED

FIGURE 8.

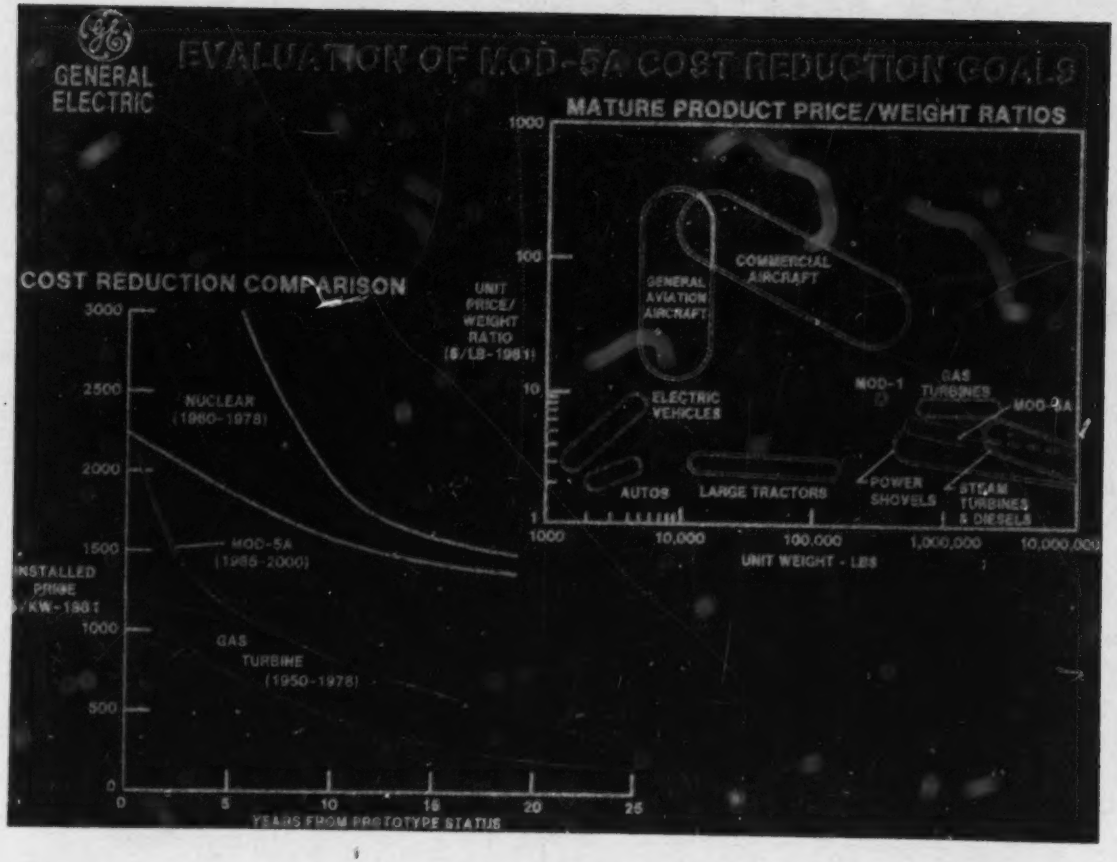

GENERAL ELECTRIC
EVALUATION OF MOD-5A COST REDUCTION GOALS
COST REDUCTION COMPARISON
INSTALLED PRIME $/KW-1981
3000
2500
2000
1500
1000
500
0
NUCLEAR (1960-1978)
MOD-5A (1985-2000)
GAS TURBINE (1950-1978)
0
5
10
15
20
25
YEARS FROM PROTOTYPE STATUS
UNIT PRICE/ WEIGHT RATIO ($/LB-1981)
MATURE PRODUCT PRICE/WEIGHT RATIOS
1000
100
10
1
GENERAL AVIATION AIRCRAFT
COMMERCIAL AIRCRAFT
ELECTRIC VEHICLES
MOD-1
GAS TURBINES
MOD-5A
AUTOS
LARGE TRACTORS
POWER SHOVELS
STEAM TURBINES & DIESELS
1000
10,000
100,000
1,000,000
10,000,000
UNIT WEIGHT - LBS

FIGURE 9.

Mr. HARKIN. Thank you very much.

Mr. Lacy? Your prepared testimony will be made a part of the record.

STATEMENT OF ROBERT G. LACY, MANAGER, HEBER BINARY PROJECT, SAN DIEGO GAS & ELECTRIC CO., SAN DIEGO, CALIF.

Mr. LACY. Good afternoon. My name is Bob Lacy and I am the project manager for San Diego Gas & Electric Co., on our Heber binary cycle powerplant.

The binary cycle is one in which heat from the hot geothermal fluid is transferred to another liquid called a working fluid. The working fluid is vaporized to drive a turbine generator. The binary cycle permits the selection of a working fluid that can be tailored to the temperature of a particular geothermal reservoir and, thereby, permits us to use that heat that might otherwise be lost if we were to use an alternate technology.

This flexibility allows the generation of electricity from moderate temperature reservoirs. Moderate temperature reservoirs are those that have heat in the range of 210 degrees celcius and lower.

To help give you some gage on the importance of this technology, 80 percent of the geothermal reservoirs in the United States are moderate-termperature reservoirs; only 20 percent are at temperatures above 210 degrees celcius. These moderate-temperature reservoirs can only be developed with a binary technology.

Another way to give you some calibration is to examine the total electric production that might be developed from a hydrothermal reservoir. The Federal Government has established a goal of 25,000 megawatts of capacity by the year 2000; this equates to about 340 million barrels of oil each year.

The Heber binary project could pave the way for the development of at least half of that 25,000 megawatt goal.

It should also be noted that the binary technology goes hand-in-glove with two other geothermal research areas. Those are hot dry rock and geopressure. Both will require the binary technology for exploitation for electric generation.

Since I appeared, I think it was a year ago today as a matter of fact, a great deal of progress has been made on the project. Union Oil has been selected as the heat supplier and negotiations are complete with that company. Union will be initiating pump well and pump tests at the site later this spring.

Engineering is well along. All of the plant systems are defined and are in the process of being released to detailed engineering. This will result in the preparation of construction drawings for construction that will start later this year.

We have maintained the project schedule. In fact we are now looking at a possibility of squeezing 3 to 6 months out of the project so far a change in my experience the end date might be moving closer rather than farther out in time.

We are in the process of receiving and evaluating proposals for all of the major equipment. In fact, through the end of this fiscal year, the total project expenditures, including commitments for all of this major equipment that will be in place by that time, will be just under $60 million.

I should point out, too, that that number does not include sunk costs in the project of about $25 million that was completely funded by the private sector.

The industry, if you look at our participants in the project, which include DOE, the Electric Power Research Institute, Southern California Edison Co., the Imperial Irrigation District, and the California Department of Water Resources, is obviously united in support of the project. We know, and I, personally, know from past experience, that additional funding is not available in significant amounts to make up shortfall costs by withdrawal of DOE funding from the project.

In 1978 we canvassed the utility industry in an unsuccessful attempt to pursue the project with private funds. In 1979 we tried again; again unsuccessfully. The private funding we have now for the project is the maximum we have been able to obtain.

In closing, I would like to make seven points that I think justify your continued strong funding support for the project.

The project will permit the achievement of at least half of the 25,000 megawatt goal from geothermal reservoirs by the year 2000.

It is an environmentally benign source of electricity.

It is essential to the commercial development of hot dry rock and geopressure geothermal energy resources.

The cooperative agreement between our company and DOE which I have not gone into here orally, but is in my testimony, is beneficial to both parties and provides DOE, with significant protection.

The industry has already made a large financial commitment to the project.

Major progress is being made and momentum is picking up very quickly on the project.

Finally, we cannot complete it without continued Federal support.

Thank you very much.

[The prepared statement of Mr. Lacy follows:]

STATEMENT OF ROBERT G. LACY
MANAGER - HEBER BINARY PROJECT
SAN DIEGO GAS & ELECTRIC COMPANY

Mister Chairman and Members of the Subcommittee, my name is Robert G. Lacy, the Project Manager of the Heber Binary Project for San Diego Gas & Electric Company. The Project is a 65 Mw (gross) binary cycle power plant. It will be the first commercial size plant of its kind in the world. As Project Manager, I am responsible for the design, construction, start-up, and demonstration of the Project.

I am a registered professional engineer in the State of California. I am a member of the American Society of Mechanical Engineers, and a member of the Board of Directors of the Geothermal Resources Council. I am also a member of the Advanced Power Systems Division Committee for the Electric Power Research Institute (EPRI); this Committee is responsible for providing direction to the EPRI geothermal program.

Before I begin my statement, I would like to thank this Subcommittee for the opportunity to discuss the Heber Binary Project. I would also like to express my appreciation for the leadership role shown by the House Science & Technology Committee during the last five years in support of the Project.

My statement will discuss the importance of the binary cycle to the development of geothermal resources and the urgency to demonstrate this technology. I will update you on the major progress made on the Project. I will also stress the importance of federal funding to the Project and the minimal burden on the federal government in view of the Cooperative Agreement with DOE. Finally, I will explain the unacceptable consequences that withdrawal of federal funds would have on the Project.

When this Subcommittee reviews federal funding for the Heber Binary Project, the following points must be considered:

1. The Interagency Geothermal Coordinating Council has established the goal of 25,000 Mw of electric capacity from hydrothermal reservoirs by the year 2000. This equals about 340 million barrels of oil each year. The binary cycle will account for at least half of the 25,000 Mw goal and could account for all 25,000 Mw.

2. The binary cycle must be developed because hydrothermal reservoirs do not have uniform characteristics.

3. The binary cycle must be demonstrated on a commercial scale before the electric utility industry can use hot dry rock and geopressure geothermal resources.

4. Unlike the binary cycle, the conventional, well-established flash cycle has an adverse impact on the environment through the release of noncondensable gases, which often include hydrogen sulfide.

5. The private sector has already made a large financial commitment to the Project and will pay fifty percent of Project costs.

6. The private sector cannot provide the additional financing necessary to move the Project forward without continued federal funding. Withdrawal of the federal funding would cause the termination of the Project.

7. The General Accounting Office (GAO) report on the Project, which was prepared at the request of this Subcommittee, affirmed the importance of the binary cycle and the need for continued federal funding for the Project.

8. Significant progress has been made on the Project and the momentum is picking up daily. The Project is on schedule.

9. The Cooperative Agreement that was signed by DOE and SDG&E to carry out the Project benefits both parties. DOE is not liable for cost overruns. The government contributions could be returned through revenue sharing.

10. The Project will reduce technical risks and should break down financial barriers to commercial use of the binary technology by the private sector.

11. National goals for geothermal development by the year 2000 would almost certainly not be met without the Project.

NEED FOR BINARY DEMONSTRATION

The binary cycle must be developed because hydrothermal reservoirs are not uniform. Reservoirs are different in size, temperature, dissolved solids, heat content, and chemical composition. Therefore, a single technology will not satisfy the requirements of full-scale geothermal development. Single- and multi-stage direct flash cycle and the binary cycle will all be required and will play important roles in geothermal development.

The utility industry has only one commercially available cycle that may be used to develop liquid-dominated hydrothermal reservoirs--the flash cycle. With the flash cycle, the hot geothermal fluid flows under pressure to a vessel where the fluid is allowed to boil, or flash, to produce steam. The steam then runs the turbine in a conventional manner. The flash cycle is well proven and has been in commercial service for a number of years, but its use is limited to high temperature (over 210°C) reservoirs and cannot be used at moderate-temperature reservoirs. The binary cycle will be used on the moderate-temperature (below 210°C) reservoirs, which represent 80% of the hydrothermal reservoirs in the United States.

The binary cycle will overcome the limitations of the flash cycle. This concept uses heat exchangers to transfer heat from the hot geothermal fluid to another liquid known as the working fluid. The working fluid is heated and vaporized and then used to drive the turbine to produce electricity. The advantage of this approach is that a working fluid can

be selected which has a boiling point equal to the prevailing temperature, either high or low, of the geothermal resource. The amount of energy production is limited only by the ambient air temperature. This flexibility allows us to generate electricity from the moderate-temperature reservoirs and improve resource utilization at other reservoirs. The binary cycle has been used on a small-scale in other industries, but has not yet been developed for full-scale commercial power generation. The 5 Mw Raft River Project and the 10 Mw Magma Project are pilot plant efforts to generate electricity. These projects will not be relied upon by the electric utility industry to make decisions for commercial scale power plants. Our objective with the Heber Binary Project is to advance the binary cycle to commercial maturity. Simplified flow diagrams for the flash cycle and binary cycle are shown in Figure 1.

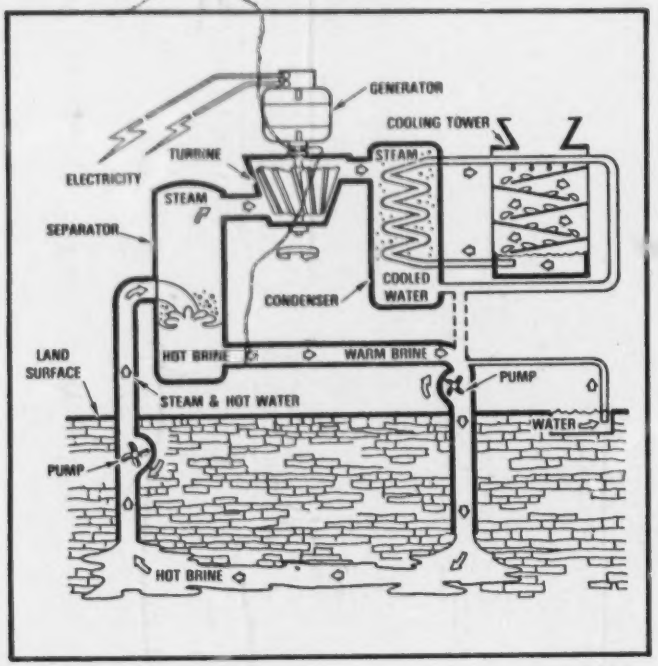
To gauge the importance of the binary cycle, about four out of five hydrothermal reservoirs in the United States are moderate-temperature reservoirs and will require the binary cycle for both technical and economic reasons. Furthermore, if, as expected, reservoir temperatures decline with time, the need for the binary cycle will become even greater.

Another way of measuring the need for the binary cycle is to examine the total electric production that can be developed from hydrothermal reservoirs. In June 1980, the Interagency Geothermal Coordinating Council, chaired by DOE, established the goal of 25,000 Mw of electric capacity from hydrothermal reserviors by the year 2000. This equals about 340 million barrels of oil each year. The binary cycle will account for at least half of the 25,000 Mw goal. In fact, the binary cycle could account for all of the 25,000 Mw because it is applicable to all reservoirs over the entire spectrum of reservoir temperatures.

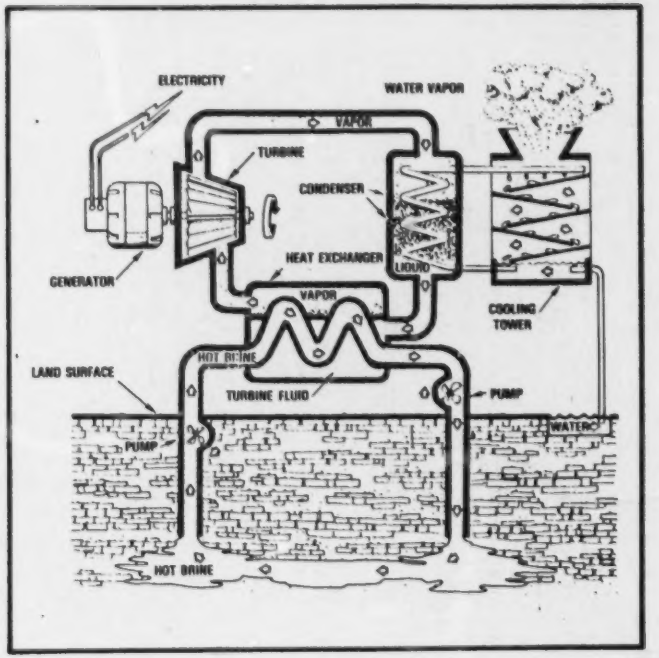
The binary cycle also provides other potential advantages over the flash cycle, such as greater efficiency of energy extraction, elimination of noncondensable gas emissions, and elimination of steam carryover problems. Such advantages could make the cost of construction and operation of a binary cycle plant lower than the cost of a similarly sized flash plant, significantly reduce the amount of auxiliary energy required to operate the plant, and minimize its environmental impact.

The Heber Binary Project is essential to advance the state of the art to commercial maturity and to further develop binary cycle power plant components. To demonstrate the commercial viability of a binary cycle geothermal plant, turbines and other systems must be manufactured, tested, and operated. Although preliminary designs for commercial size binary turbines have been prepared, they have never been built or operated. Other areas where development or verification must be accomplished prior to commercial application include downhole well pumps; plant and component reliability; safety and environmental impacts; heat exchangers; working fluid characteristics; waste control technology, such as cooled brine reinjection; and plant operating procedures and performance.

FLASH SYSTEM



BINARY SYSTEM



On November 12, 1980, this Subcommittee asked the General Accounting Office to perform an independent evaluation of the Heber Binary Project and, in particular, to assess the impact, on the Project of the withdrawal of federal funds. Their report to you concluded that a large majority of the nation's hydrothermal geothermal resources can be effectively used only with the binary cycle technology. The report further concluded that elimination of federal funding would cause the Project to be terminated resulting in failure to meet our national energy objectives.

The Binary Cycle Is Essential to Commercialization of Hot Dry Rock Resources

Hot dry rock resources will not be used by the electric utility industry unless the binary cycle is demonstrated on a commercial scale.

A hot dry rock resource is defined by DOE as heat stored in rocks that contain little or no water. The lack of sufficient water to transport the heat distinguishes hot dry rock from naturally occurring hydrothermal reservoirs. Hot dry rock resources occur throughout the United States in extremely large quantities. Los Alamos Scientific Laboratory has estimated that if as little as 2% of this vast resource base could be exploited, it would supply the entire country's nontransportation energy needs at the present rate of consumption for more than 2000 years.

To extract energy from a hot dry rock resource, a manmade hydrothermal reservoir is formed by connecting two deep holes in impermeable rock through a system of fractures in the rock which are produced by pressurizing water. Cold water flows down the deeper hole, is heated by the hot rock in the underground fracture system, and is brought to the surface in the second hole under sufficient pressure to keep it from boiling or flashing. After the hot water runs through a heat exchanger at the surface, it is pumped back down the injection hole. Because the hot water is kept under pressure, the only way to use its heat is to transfer it to a working fluid in a heat exchanger. This constraint dictates the use of the binary cycle if the heat is to be used to generate electric power.

The Binary Cycle Is Applicable to Geopressure-Geothermal Resources

Water-bearing reservoirs, characterized by significantly higher temperatures and pressures than their depth would suggest, have been discovered along the Gulf Coast and other areas of the United States. These reservoirs, called geopressured aquifers, contain three forms of energy:

1. Chemical energy - Considerable amounts of natural gas, or methane, could be dissolved in the waters of these aquifers.

2. Thermal energy - The relatively high temperature of the waters could be used for the generation of electricity using the binary cycle.

3. Mechanical energy - The high water pressure could be used to drive turbines.

Recovery of methane is the primary target of the DOE Geopressure Geothermal Program. If the methane can be produced at competitive cost, use of the thermal and mechanical energy will follow--provided the binary cycle is commercially available to the electric utility industry.

Geopressured aquifers are estimated to contain between 3,000 and 50,000 quads of energy and constitute a major U.S. energy target.

The goals of the DOE Geopressure Program are to determine:

1. The magnitude of the resource base,

2. The amount of the methane that is technically feasible to produce,

3. The probable production lifetimes of individual resrevoirs,

4. The economics of developing the thermal and mechanical energy, assuming methane recovery is economical, and

5. To resolve associated environmental and institutional barriers.

All of the geopressured aquifers which have been evaluated as part of the DOE Program contain low- to moderate-temperature water (below 210°C).

The binary cycle has to be used to convert this energy to electricity. This fact was acknowledged by DOE when it proposed the use of Total Energy Systems as a potentially attractive way to integrate the three forms of geopressured aquifer energy (chemical, thermal, and mechanical) into a commercial system. The proposed binary cycle plant, which is part of the Total Energy System, would use a cycle like the Heber Binary Project.

SDG&E BACKGROUND IN BINARY CYCLE DEVELOPMENT

SDG&E has conducted geothermal exploration, research, and field test development since early 1971. SDG&E began conducting field tests applicable to binary cycle technology in 1973. Small heat exchangers, with the hot, highly mineralized brine flowing directly through the tubes, were used to heat a working fluid. These tests revealed the high scaling tendencies of the brines at the Niland reservoir in the Imperial Valley, and the company set about to develop ways to overcome this problem. In 1974, a multi-stage flash/binary system was designed. It removed heat from the geothermal fluid in the form of steam. Based upon field tests of this system and under a 50-50 cost sharing arrangement with DOE, SDG&E built and operated a 10 Mw Geothermal Loop Experimental Facility (GLEF) to evaluate the practicality of the flash/binary conversion process.

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Valuable experience, of direct benefit to the Heber Binary Project, was gained through the design, construction, and operation of the GLEF. Special construction techniques were employed for the desert soil and weather conditions of the Imperial Valley. Operational problems, such as high injection well pressures, scale deposition, and erosion of plant piping and components were identified and overcome. The GLEF also provided insight into plant cleaning operations and reservoir performance and furthered the development of important plant components.

To determine scaling characteristics of the Heber brine, SDG&E, in cooperation with EPRI and Chevron Resources Company, conducted heat exchanger tests at this reservoir in 1974. These tests consisted of a series of 500-hour runs with four small heat exchangers and three different tube materials. The results of these tests were published in EPRI Report ER-376, "Final Report of Test and Evaluation of a Geothermal Heat Exchanger," September 1975.

EPRI followed up the first 500-hour heat exchanger test with a 2000-hour test, which verified the findings of the first scaling and corrosion tests. The quantity of noncondensable gas in the brine was also determined. Results of this test were published in another EPRI Report ER-572, "Final Report of Geothermal Heat Exchanger at Heber, California," August 1978. Data from the testing program formed the basis for full-scale design criteria for the Heber Binary Project.

HISTORY OF THE HEBER BINARY PROJECT

The Heber Binary Project had its beginning in a study performed for EPRI by Holt/Procon. The purpose of the study was to evaluate alternate technologies that could exploit the extensive low- to moderate-temperature geothermal reservoirs in the United States. The study also screened 17 candidate reservoirs to determine which would be best to demonstrate the selected technology on a commercial scale. The results of the study were published in 1976 and 1978 as EPRI Reports ER-299, "Geotechnical Environmental Aspects of Geothermal Power Generation at Heber, Imperial Valley, California," October 1976; ER-301, "Geothermal Energy Conversion and Economics--Case Studies," November 1976; ER-364, "A Comparison of Hydrothermal Reservoirs of the Western United States," December 1976; and ER-670, "Preliminary Design Manual for a Geothermal Demonstration Plant at Heber, California," February 1978. The study concluded that the binary cycle showed the most promise for application to low- to moderate-temperature reservoirs, and that the Heber reservoir was one of the best sites to demonstrate the technology on a commercial scale.

In 1977, SDG&E agreed to manage a demonstration project with a capacity of 65 Mw (gross) that would be located on the Heber reservoir. This decision was based on SDG&E's extensive geothermal experience and EPRI's supporting work. Consequently, a project was formed with participation by SDG&E, EPRI, six other utilities, two reservoir developers, and the California State Energy Commission. Engineering and environmental

studies were initiated and efforts were made to obtain federal funding for the portion of project costs that could not be financed by industry. In 1978, federal funding was not forthcoming and because the risk of this first-of-a-kind project was greater than industry could assume, the project was terminated.

In 1979, when DOE was directed by Congress to proceed with the demonstration of the binary cycle on a commercial scale, SDG&E again submitted a project proposal. This proposal was accepted by DOE, and in September 1980 the parties signed a Cooperative Agreement. Other agreements to carry out the newly-formed project have been signed with EPRI and a group of three utilities--the Imperial Irrigation District, California Department of Water Resources, and Southern California Edison Company.

It is important to note that substantial progress was made on the Project prior to signing the Cooperative Agreement with DOE--all of it funded by the private sector. For instance:

1. Extensive reservoir exploration and evaluation were completed.
2. The plant conceptual design was in place.
3. Engineering trade-off studies were performed.
4. Turbine-generator conceptual designs were completed.
5. Environmental studies were completed.
6. A land use permit was obtained from Imperial County.
7. The site was acquired.
8. An assured source of cooling water was acquired.

PROJECT ORGANIZATION AND FUNDING

SDG&E has formed a consortium to fund and operate the Project. The contributions to funding and ownership interests of the six participants are as follows:

PARTICIPANT	FUNDING	OWNERSHIP
Department of Energy	50.0%	---
Electric Power Research Institute	10.0%	---
San Diego Gas & Electric	32.8%	86.3%
Imperial Irrigation District	4.0%	10.5%
Department of Water Resources	1.2%	3.2%
Southern California Edison	2.0%	---

SDG&E is responsible for managing the Project, including its design, construction, start-up, and demonstration.

CURRENT STATUS OF THE PROJECT

Union Oil Company has been selected as the geothermal heat supplier for the Project and negotiations for the heat sales contract are complete. Union will be initiating pump and well tests at the site this Spring.

A contract has been signed with Fluor Power Services to perform the engineering design work for the Project. All plant systems have been defined and are in the process of being released for detailed engineering. Detailed engineering will result in the preparation of construction drawings to be used when construction starts later this year.

Dravo Utility Constructors, Inc. (DUCI) has been selected as the Construction Manager and has assigned key personnel to San Diego. These personnel are preparing the detailed construction schedule and are working with Fluor, the Architect/Engineer, to prepare construction bid packages.

Despite the uncertainty of continued federal funding, we have maintained the Project schedule. In fact, we are now considering the option of advancing the scheduled date for completion of construction by three to six months.

The following is the latest status on major equipment procurements for the Heber Binary Project and the estimated cost.

1. The manufacturer has been selected for the turbine-generator. The value of the procurement contract is approximately $6,100,000.

2. Proposals have been received for the main transformer. The proposals are now being evaluated and the estimated value of the procurement contract is $500,000.

3. Proposals have been requested on twelve items of equipment and selections will be made in the near future. The estimated total value of these procurement contracts is $5,514,000.

4. Proposals will be requested on the remaining thirty-four pieces of major equipment within the next few weeks. The total estimated cost of these procurement contracts is $35,636,000.

Through the end of Fiscal Year 1982 the total Project expenditures, including commitments we will make for all of the equipment will be approximately $59,756,000. It should be noted that this number does not include costs totaling approximately $25,600,000 incurred solely by the private sector for reservoir exploration and development, field testing, environmental studies and plant conceptual design.

FEATURES OF THE COOPERATIVE AGREEMENT THAT ARE FAVORABLE TO THE GOVERNMENT

The Cooperative Agreement differs from other more conventional contracts used by DOE to fund projects. It recognizes that the Heber Binary Project is a partnership, with the private sector bearing a major part of the risks. It permits the Project to be managed by the private sector with minimal burden on DOE.

The private sector has a large financial interest in the Project and, consequently, a great incentive to achieve success.

Some of the key features of the Cooperative Agreement that are favorable to the government include:

1. A revenue sharing provision which will return to DOE the government contribution if the demonstration power plant is successful and can be operated as a commercial facility.

2. A ceiling on government financial exposure so that if the cost ceiling is exceeded, the government has no liability for cost overruns.

3. Provisions for the broad dissemination of data from the Project to industry so that others interested in making commercial commitments to the binary cycle can do so with minimal risk.

EFFECT OF DOE WITHDRAWAL

SDG&E, like the rest of the utility industry, is experiencing financial constraints that prevent it from undertaking completely on its own a demonstration power plant like the Hebery Binary Project. By law, SDG&E is required to meet the needs of its existing and future customers; consequently, its scarce financial resources must be used to add commercial generating plants and related transmission lines and to accomodate new customers on its system. With the approval of the California Public Utilities Commission, we have reallocated our limited R&D budget to provide our share of the funds to the Heber Binary Project. SDG&E cannot provide additional funds.

Furthermore, the company does not believe that the funding shortfall that would result if federal funds were not provided to the Project could be replaced by industry or the other Project participants. In 1978 when federal funding for the Project was not granted, SDG&E and EPRI canvassed the utility industry in an effort to replace what was then a much smaller shortfall; these efforts were unsuccessful. In 1979, SDG&E again tried unsuccessfully to obtain additional financial participation. The electric utility industry cannot fund demonstration projects on its own. We are having enough difficulty obtaining the capital needed to meet our customers' needs using proven technology. The non-federal funding which we now have for the Project is the maximum we can obtain. While industry is united in its support and need for the Project, sufficient additional funding is simply not available to permit the Project to go forward without federal support.

Without federal funding this essential Project will be abandoned. The likelihood of its being resurrected and completed in the near future is negligible. As a result, four out of five of the hydrothermal reservoirs in the United States will not be developed.

CONCLUSION

In conclusion, I urge this subcommittee to demonstrate your continued support for the Heber Binary Project. Funding in Fiscal Year 1983 is essential if the Project is to proceed. Justification for your continued support includes:

1. Binary cycle will permit the achievement of at least half of the 25,000 Mw goal.

2. The binary cycle is an environmentally desirable source of electricity.

3. The binary cycle is essential to the commercial development of hot dry rock and geopressure geothermal energy resources.

4. The Cooperative Agreement between DOE and SDG&E is beneficial to both parties.

5. Industry has already made a large financial commitment to the Project.

6. Major progress has already been made on the Project that would be lost if the Project is abandoned.

7. The Project cannot proceed without continued federal funding.

Mr. HARKIN. Thank you very much.

Mr. Germain, Los Alamos, hot dry rock geothermal, how are you doing on it? Your written testimony will be made a part of the record.

STATEMENT OF LAWRENCE S. GERMAIN, DEPUTY ASSOCIATE DIRECTOR, ALTERNATE ENERGY SOURCES, LOS ALAMOS SCIENTIFIC LABORATORY, LOS ALAMOS, N. MEX.

Mr. GERMAIN. Thank you, Mr. Chairman, that is what I hope to tell you about today.

I am Larry Germain. I am programatically responsible for nonnuclear energy programs at the Los Alamos Laboratory. I would like to give you a kind of status report on hot dry rock.

A little bit of background: I do not think many people appreciate how much energy there is in the form of geothermal energy. The potential geothermal energy in this country exceeds the fossil and nuclear resources combined; the trick is how to use it.

In a few cases nature is very helpful and hot water or steam will come from drill holes but that method of exploitation is possible for only far less than 1 percent of the existing geothermal energy. Most of the energy is tied up in the form of heat which exists in rocks at depth.

We needed a good idea of how to extract that and we think we have one. About 10 years ago scientists at the Los Alamos Laboratory initiated a project to essentially mine this heat. By drilling two holes in the ground, connecting them with one or more fractures, flowing cold water down one hole and hot water up the other hole, then the sensible energy could be extracted at the surface.

This proposal was funded by the then AEC and a hot dry rock program was initiated at Los Alamos about 8 years ago.

Mr. HARKIN. It was ERDA who did that.

Mr. GERMAIN. No; it was started in AEC. It has been carried on by ERDA and DOE; that is how old it is.

One interesting point: two countries whose more traditional energy reserves are minimal are keenly interested in the potential of this program to develop energy self-sufficiency. Under an international energy agency agreement, agencies of the Federal Republic of Germany and the Government of Japan have provided supplemental support since fiscal year 1980. That is supposed to run through fiscal year 1983 incidentally in the form of both money and scientific personnel.

We have succeeded in creating a hot dry energy geothermal loop. We have connected two holes and have circulated the loop for 9 months. We have found the results to be good, there was little water loss, the system was environmentally benign, the water quality remained good and all aspects of the program appeared promising.

Except that this system was clearly not economical because we extracted only about four megawatts of thermal energy and had to pay the price for drilling two rather deep holes.

We then set about to create a hot dry rock reservoir which would more closely resemble an industrially useful one. We drilled two deeper, hotter holes going to a depth of 14,400 feet and a rock temperature of about 620 degrees fahrenheit. We have deviated the bottoms of those holes at 35 degrees for 3,000 feet so that we may connect them, hopefully, with multiple fractures and position them such that one hole is 1,250 feet vertically above the other.

These are two of the deepest and hottest geothermal wells ever drilled and precisely controlled directional drilling in very hard, very hot rock is unique in drilling history.

Mr. HARKIN. Excuse me for interrupting, are they done?

Mr. GERMAIN. They are done.

Mr. HARKIN. Have they fractured the rock yet?

Mr. GERMAIN. No; that is the next step.

The DOE has cited, as a goal for 1983, the orderly termination of the hot dry rock program. Orderly termination, at least in my opinion, should include the removal of the remaining technical uncertainties in the path to commercialization. We feel these uncertainties to be the creation of the multifracture reservoir, which you just mentioned, the control of flow through these parallel fractures if that turns out to be necessary, and the determination of usable reservoir lifetime, since the utilities will not invest in the reservoir unless it has a reasonably long life.

We have a program to answer these questions. We will first determine the best way to create multiple fractures in hot granitic rocks and after a brief test create the remaining multiple fractures and then follow with a period to determine reservoir lifetime.

Our plan is to create two or more hydraulic fractures from the lower part of the deeper hole, and connect them with the upper hole. The hydraulic-fracturing equipment and methods so far used at Los Alamos and by industry must be modified extensively for use in this very hot, inclined borehole; we expect to experiment

with several fracturing approaches. We expect problems, but we are confident that we can make the connections.

We will then circulate water through the system for a few months and then bring back the workover rig, produce the additional fractures and operate the large heat extraction loop at about 20 megawatts thermal extraction for a long enough period, hopefully, to determine reservoir lifetime.

DOE funding is presently $2.5 million as I understand it, and it should be pointed out that if DOE funding falls below $5 million we lose dollar for dollar the same amount in foreign contributions from Germany and Japan as the DOE funding falls below the $5 million figure.

Under these conditions we will only be able to conduct the first series of fracturing experiments and limited reservoir testing. We do not feel that the major technical uncertainties will be removed. An absolute minimum of $5 million of DOE funding and the associated funding from Germany and Japan are required to carry out the full fracturing experiment. Even this funding has no allowance for contingencies. This fracturing is a first-of-a-kind experiment, difficulties have to be expected, and there certainly are hazards proceeding without contingency funds.

A more prudent program would be $2.5 million more for contingencies. Even then, we might not have sufficient time in fiscal year 1983 to test the reservoir long enough to make a good estimate of its lifetime.

Most large energy companies and several industrial consumers of large quantities of heat have been and are interested in the hot dry rock program and have kept abreast of its progress. In general, they consider it a high-risk, high-payoff program of a type particularly appropriate to a national laboratory. Many have been helpful in advising us of their experiences and cooperating and developing special equipment and instruments that we have needed; however, none has yet been motivated to participate directly in the program and you can hardly blame them since the technology still remains to be fully developed and there are uncertainties about the economics of the hot dry rock system, although preliminary studies on economics are very encouraging.

Accordingly, their primary interests are still in the shorter range rewards of finding, producing and using energy from the more traditional sources.

As I said at the beginning, we believe that the stakes are very large in hot dry rock because the potential resource is great and we feel, of course, that it is of considerable importance to carry this development to a logical conclusion.

We think it is important to the Nation that this development be concluded to the point where we can prove or did prove the viability of the larger reservoir and this will only be done if there is continued Federal support for an aggressive hot dry rock program.

I thank you very much.

[The prepared statement of Mr. Germain follows:]

Hot Dry Rock Geothermal Energy
Facts and Prognosis

Lawrence S. Germain

Deputy Associate Director
Alternate Energy Sources
Los Alamos Scientific Laboratory

FACT SHEET - HOT DRY ROCK

Geothermal energy is natural heat in the earth's crust. It exists everywhere beneath us, and just that small fraction of it that is present at currently accessible drilling depths is sufficient to satisfy man's energy needs for thousands of years.

Hydrothermal reservoirs--natural steam and hot water trapped in the crustal rock--are an important energy resource, but represent much less than 1% of the total geothermal energy supply. More than 99% of that energy is in the rock itself. This heat--the hot dry rock resource base--is an inherently clean and essentially inexhaustible supply of energy.

In the scientific community, the potential usefulness of hot dry rock geothermal energy has been recognized for more than a hundred years, and over the years many proposals have appeared for extracting and using it. Until recently, however, obvious technical, economic, or environmental difficulties with all of these concepts have discouraged any attempt to develop or use them. A better idea was needed, and in 1970 a group of scientists at Los Alamos came up with one.

By that time, hydraulic fracturing was a common technique for increasing production from oil, gas, and water wells. Most simply, it involves pumping water into a well until the downhole pressure is sufficient to split the wall of the hole. By simply continuing to pump, the resulting cracks can then be extended outward from the well for hundreds or thousands of feet. To the Los Alamos group, this seemed an ideal way to create the flow passages and heat-transfer

surface required to extract heat efficiently from deeply buried hot rock. Accordingly, after preliminary studies had indicated that the method was probably feasible, a proposal was made to investigate the possibilities and problems on an energy system in which two holes drilled into the hot rock would be connected at depth by hydraulic fracturing. Cool water pumped down one hole would be heated as it circulated through the fractures. It would be recovered through the second hole; its useful heat removed at the surface; and the water recirculated to recover more heat.

This proposal was funded by AEC, and a Hot Dry Rock Program was initiated at Los Alamos about eight years ago. It has since been supported successively by ERDA and DOE. Two countries whose own more traditional energy reserves are minimal are keenly interested in the potential of this program to develop energy self-sufficiency. Under an International Energy Agency (IEA) Agreement, agencies of the Federal Republic of Germany (FRG) and Government of Japan (GOJ) have provided supplementary support since fiscal 1980, in the forms of both money and scientific personnel.

Beginning in 1973, the world's first hot dry rock energy system has been constructed and successfully operated at Fenton Hill, about 20 miles west of Los Alamos. The hydraulically fractured underground loop is in granitic rock at a depth of 8500 feet where the rock temperature is 365°F. The system has been operated as a recirculating pressurized-water heat-extraction loop for periods up to nine months, with heat-extraction rates up to 17 million BTU/hr--the equivalent of 70 barrels of oil per day. There have been no problems from scaling or corrosion. Water loss has been low; water quality has remained good; and there have been no detectable environmental effects from system operation. Because of thermal contraction of the reservoir rock as heat was extracted from it, the underground fracture system spontaneously increased in volume, a very important property which could have an important effect on reservoir size and lifetime.

On a fluid bypass from the main Fenton Hill circulation system, an experimental 60 kW power plant has been operated intermittently. Heat from the recirculating water is used to boil Freon, whose vapor drives a turbine that turns an alternator to produce 3-phase current that is used at the site. This unit has operated well, but at low efficiency because of the low temperature of the inlet water--only about 275°F. For a commercial power plant, heat is required at a higher temperature and rate and for a longer time than the projected useful lifetime of this pioneering research system.

To approach more nearly the requirements of a commercial plant, a larger, deeper, hotter hot dry rock system is now being constructed at Fenton Hill. Two new wells have been completed. The first was drilled to a vertical depth of 14,400 feet, where the rock temperature is 620°F. Its bottom 3000 feet were directionally drilled at 35° to the vertical to provide horizontal space for a series of well-separated hydraulic fractures. The second well is 150 feet away at the surface but, in its lower, inclined section it is 1250 feet vertically above the first one. These are two of the deepest and hottest geothermal wells ever drilled; and the precisely controlled directional drilling in very hard, very hot rock is unique in drilling history.

The DOE has cited a goal of orderly termination of the Hot Dry Rock Program in FY83. Orderly termination in our opinion, should include the removal of the remaining major technical uncertainties in the path of commercialization. We feel these to be: the creation of a multi-fracture reservoir, the control of flow through these parallel paths and the determination of the usable reservoir lifetime. We have a program plan to answer these questions. We will first determine the best way to create multiple fractures in hot granite rocks. After a brief test period the remaining multiple fractures will be created, followed by an extensive period of testing.

Our plan is first to create two or more hydraulic fractures from the lower part of the deeper hole, and drive them upward to intersect the upper one. A workover rig will be on site within a few days for this operation. The hydraulic-fracturing equipment and methods so far used at Los Alamos and by industry must be modified extensively for use in this very hot, inclined borehole--and we intend to experiment with several fracturing approaches. We expect problems, but we are sure that we can make the necessary connections.

We will then circulate water through the system for several months to investigate heat-transfer areas and flow-impedance of individual fractures, determine whether downhole flow-control devices are needed, and study the chemistry of the recirculated fluid. We will then return the workover rig to create the additional fractures and operate the enlarged heat-extraction loop for a sufficient period to demonstrate reservoir lifetime.

The DOE funding presently planned for HDR in FY83 is about $2.5M. It should be pointed out that if DOE funding falls below $5M, the IEA agreement calls for a proportional decrease in FRG and GOJ funding. Under these conditions we will only be able to conduct the first series of fracturing experiments and limited reservoir testing. The major technical uncertainties will not be removed. An absolute minimum of $5M of DOE funding and associated funding from FRG and GOJ are required to carry out the full fracturing planned and to create a reservoir approaching the requirements of a commercial plant. Even this funding has no allowance for contingencies. In conducting a first-of-a-kind experiment, difficulties must be expected and there are hazards associated with proceeding without adequate contingency funds. A prudent program would be one which added $2.5M for contingencies. Even with the above program there is not sufficient time to complete a definitive reservoir draw down test in FY83. The tests would have to be continued into FY84 before a good estimate of the reservoir lifetime could be obtained.

Most of the large energy companies and several industrial consumers of large quantities of heat have been and are interested in the Hot Dry Rock Program, and have kept abreast of its progress. In general they consider it a high-risk, high-payoff program, of a type particularly appropriate to a National Laboratory. Many have been helpful in advising us from their own experience and in cooperating in development of the special equipment and instruments that we have needed. However, none has yet been motivated to participate directly in the program. Since the engineering technology still remains to be fully developed, they are uncertain about the economics of hot dry rock energy systems, although preliminary studies are most encouraging. Accordingly, their primary interest is still in the shorter-range rewards of finding, producing, and using energy from the traditional sources.

Hot dry rock is by far the largest of our usable, accessible, energy sources. It is broadly distributed and uninterruptable. We have demonstrated that large amounts of useful heat can be extracted from it with no undesirable environmental consequences. Our preliminary economic studies suggest that, per unit of energy produced, it can be competitive with the fossil fuels. However, this remains to be demonstrated, together with the technology required to produce heat at the temperatures and rates required by a commercial-scale operation.

I submit that it is important to our nation that these developments and demonstrations be made, and that this will be done only if there is continuing Federal support for an aggressive Hot Dry Rock Program.

Mr. HARKIN. I will go in reverse order here. I just want to ask you something about the hot dry rock program.

About 2 or 3 years ago we put money—it has been longer than that—4 years ago. There was a problem of drill bits, getting the proper kinds of drill bits to drill through the rock. Has that been solved? Have we dealt with that problem? We put $2 or $3 million into that.

Mr. GERMAIN. We found a drill bit and I think it was a particular, commercially available drill bit that worked quite satisfactorily in drilling through the hot granitic rock.

Mr. HARKIN. So you can do that. That was pointed out as one of the really big drawbacks that you had to overcome 4 years ago.

Mr. GERMAIN. We had two problems, one was a drill bit that had a reasonable down hole lifetime and that was solved. The other was to do directional drilling—controlled directional drilling—at depth in the hot rock.

You see, when the second hole was drilled, we had to keep its position, relative to the first hole, to an accuracy of about 100 feet and this required the ability to make downhole directional corrections of the drilling. We succeeded in doing that, as well, again with instrumentation supplied and developed by industry.

Mr. HARKIN. How would you crack that rock, with water or with dynamite, or with what?

Mr. GERMAIN. Our plan is to fracture with water. The first fractures that we made were water without any additives which was rather surprising; no additives to prop the fractures open and no additives to increase or decrease viscosity—just plain water. It worked quite satisfactorily before and we hope it will work again.

Mr. HARKIN. You have been operating Fenton Hill for about 3 years now?

Mr. GERMAIN. Our main run in the first reservoir was 9 months in length. There were a number of other shorter runs so the total time frame that we have had the reservoir available was far more than 9 months. But, the main run was a 9-month long, almost continuous circulation.

Mr. HARKIN. Did you get any preliminary data on the length of reservoir time?

Mr. GERMAIN. During the 9 months the temperature of the reservoir dropped 8 degrees Celsius and is hard to predict a lifetime. It would be several years, but also we never believed that that was a large enough reservoir to have a useful lifetime and that is why we wanted to make a larger and hotter reservoir.

Mr. HARKIN. When I was at Los Alamos—I do not know if you were the one that briefed me——

Mr. GERMAIN. No; I was not.

Mr. HARKIN. In 1975 or 1976, I think that Fenton Hill was just getting underway at the time.

We talked about the length of time that the reservoir would be good and, correct me if I am wrong, I thought there was some indication that the temperature would drop and then it would level off after a while.

Mr. GERMAIN. The temperature will drop more slowly as time goes on. We have, of course, made predictions and our projection is that the phase 11 reservoir, if we succeed in making it—that is the

bigger one that we are trying to make now—will have a lifetime of 10 years with a drop of something like 20 percent in the energy extraction over the 10-year period, but that is a prediction. One of the things we do not know is how nature is going to behave.

Mr. VOLKMER. Will the gentleman yield?

Mr. HARKIN. Yes.

Mr. VOLKMER. I just wanted to ask a question on this, too. Have you a total estimated need in budget authority, whether it is 5 or 7½? And if you get those amounts, how much contributions would you receive from West Germany and Japan? What would be the total we are looking at?

Mr. GERMAIN. As long as the DOE contribution is $5 million or more, under the agreement, Germany and Japan are each obliged to supply $2.5 million per year so that the $5 million DOE money is doubled. If the DOE supplies us with $2.5 million, then the Governments of Germany and Japan are each obliged to supply $1.25 million so that the total contribution from DOE and the foreign governments would then be $5 million. So, for any number like $5 million or below, the amount of money that DOE contributes is doubled by the foreign contribution. However, $2.5 million per year is the maximum that Germany or Japan is obliged to contribute under the agreement no matter how much the DOE contribution is.

Mr. VOLKMER. The next question is, how much do you estimate it would cost to do the fracturing?

Mr. GERMAIN. The cost of bringing in the drill rig alone is about $1.5 million. Drill rigs are expensive these days.

Mr. VOLKMER. I am trying to get to the costs you have asked for, which may be up to $7.5 million. I am trying to see where the money fits in.

Mr. GERMAIN. Well, the $1.5 million for the drill rig is only part of the story because there are the other facilities that have to be brought in to do the fracturing; oil well service companies, in essence, plus our own staff's work. You see, at the lower figure of $2.5 million we would not only not do the fracturing but we would reduce staff and there is a lot of technical work that we would not do.

Mr. VOLKMER. When would you be able to do the fracturing?

Mr. GERMAIN. Well, it is in my testimony, but I did not say it. The drill rig is expected on site very shortly for the first series of fracturing experiments; the learning curve you might say. We would then expect to bring the rig back toward the end of this fiscal year—late summer or fall in the second series and the completion of the fracturing.

Mr. VOLKMER. And then if the fracturing is successful, you would run the loop?

Mr. GERMAIN. Yes.

Mr. VOLKMER. How long would it take you to do that? How long does it take you to first make your pool of water?

Mr. GERMAIN. Well, the water is another issue that I did not bring up. We need much water to carry out the fracturing and the testing of the loop but we are in the final stages of constructing a water pond onsite so that we will have the ability to store that water. We are still working on water rights.

Let me make the supposition that we have some funding through 1983 but have to terminate the program at the end of 1983. It would be my guess under those conditions that we will have run the loop about 9 months by the time we have to close down and it would also be my suspicion that after 9 months we will still have considerable uncertainty as to the value of the reservoir lifetime.

Mr. VOLKMER. How long would you prefer to run it?

Mr. GERMAIN. I would like to run it another 9 months.

Mr. VOLKMER. Eighteen months total?

Mr. GERMAIN. Yes.

Mr. VOLKMER. Thank you, Mr. Chairman.

Mr. HARKIN. What are the diameters of the holes?

Mr. GERMAIN. I think they are 8⅝ in the open hole portion below the casing which is the bottom 3,000 feet.

Mr. HARKIN. Is this the project that you were hoping would not only use the water to generate electricity for Los Alamos but then to use some for heating buildings? What was that? Was that Fenton Hill?

Mr. GERMAIN. That was another possible application. It was not Fenton Hill. Fenton Hill is 30 kilometers away from Los Alamos and you cannot pipe hot water over and keep it very hot.

We felt at one point, and we still feel, that there is a geothermal resource under Los Alamos. It may be hydrothermal rather than hot dry rock. At one point, a long time ago, there was an edict that the laboratory should stop using natural gas and we looked at the possibility of using our own geothermal resource for heating the laboratory. The edict about natural gas is no longer true, of course, and that project has been dropped. However, I continue to believe that there is a geothermal resource under the laboratory.

Mr. HARKIN. One last thing. Again, some years ago—maybe 2, 3, or 4 years ago—I thought we authorized some money for the experimental drilling of holes in various parts of the United States to get some thermal gradients.

Mr. GERMAIN. You did.

Mr. HARKIN. Was that done?

Mr. GERMAIN. Yes, I did not mention that either. One part of the program that we are—let me back up. We are putting almost all our emphasis on Fenton Hill this year to try to answer the questions that I mentioned.

Another part of the program that has been ongoing is to try to assess the hot dry rock resource throughout the country. In that we cooperated with the U.S. Geological Survey and State geologists and universities and collected all the data that we possibly could and measured some new holes as you mentioned. The net result has been publishing a thermal gradient map of the United States. An updated version of that will be produced this year. That will probably be the termination point of our efforts to study the national resource of hot dry rock. It is an interesting map. It shows significant possibilities for hot dry rock development in parts of the country that you do not ordinarily think of as having geothermal resources.

Mr. HARKIN. Iowa? The Midwest?

Mr. GERMAIN. Nebraska. I am afraid not Iowa, but Nebraska and South Dakota and along the Atlantic seaboard.

Mr. HARKIN. Maine and places like that?

Mr. GERMAIN. New Hampshire down to South Carolina there is not high grade resource but the kind of resource that requires the binary system and it certainly is potentially developable.

Mr. HARKIN. Do you have a question, Mr. Volkmer?

Mr. VOLKMER. I would just like to ask in regard to wind, how long will it take before we actually know that the system is reliable. We have two people here who have two different opinions. How long will it take for us to have sufficient reliability that we can sell the machine to users so that they can generate electricity for consumers?

Mr. DIGIOVACCHINO. My own opinion is that it will take about 2 years of operation of prototype machines or early commercial units before sufficient data is accumulated to allow serious projections regarding reliability and availability.

Mr. JACKSON. Close to that, I would say that our project, our planning involves about five machines in the first stage, followed by another dozen or more and these would be commercial run machines, operated in the commercial environment by utility people with the availability and reliability measured as you go.

Mr. VOLKMER. When will these start up?

Mr. JACKSON. Our current plans are to get them in place in 1984 or early 1985 and we expect to be able to move into a mode of selling hardware direct 2 or 3 years after that.

Mr. VOLKMER. In other words you are going to start out with your machines at the same time that MOD-5 will start up?

Mr. JACKSON. I am saying in terms of commercial, except that these will be commercial versions operated commercially. We have the two prototypes going up this summer which are the what we call production prototype.

Mr. VOLKMER. The one that is in Sweden; is that right?

Mr. JACKSON. The one in Sweden and the one in Medicine Bow, Wyo. The one in Medicine Bow is the true production prototype.

Mr. VOLKMER. Where do you see that our problems mostly are? In the generator? In the blades?

Mr. JACKSON. No, they are largely structural. These are system structural problems. They play on the interaction of all the components together. Ones they typically pick on is the blade, but it is not the way that the blade is constructed necessarily, it is the way that the whole system has been designed and how each component relates to the other.

This is the heart of the technology which has to be in place in order to develop a reliable machine. It tells you how much life each one of those components is going to have and unless you know that, you are in trouble.

Mr. VOLKMER. I get the impression that we are beyond the point where Government assistance is necessary?

Mr. JACKSON. From our standpoint, absolutely.

Mr. VOLKMER. Dan, what do you say?

Mr. DIGIOVACCHINO. In our testimony we indicated that there are significant risks left in reducing these designs to practice. We have the designs, we have the concepts and the risk is yet in front of us to get the experience of using and operating our machines.

Mr. HARKIN. Will the gentleman yield?

Mr. VOLKMER. Yes.

Mr. HARKIN. Mr. Jackson, on September 16, 1979, you testified to this subcommittee as follows, and I quote, "clearly, the MOD-5 program as well as the smaller MOD-6, are essential programs to the continued reduction of energy costs. These programs should be continued to fruition and in each case, parallel developments involving more than one contractor should be supported." That is your quote.

Why are you now testifying in opposition to the MOD-5? What has changed since September 1979? And, does your position in any way reflect the fact that you lost the competition for MOD-5?

Mr. JACKSON. Well, it would be ridiculous for me to deny that the loss to the competition on the MOD-5——

Mr. HARKIN. Made you happy? [Laughter.]

Well, forget about that question. Why are you testifying in opposition? What has changed?

Mr. JACKSON. As I indicated in my testimony first of all, the first point was that—even in my testimony at that time—we strongly believe that the most important part of the Wind Energy Act was the public phase of it which was getting out with machines in the marketplace to get commercial experience on them and to establish basically an experience base from which you could judge reliability. We also are very sensitive to the lack of data, which has still not been corrected incidentally, of the wind resource in the detailed sense so that the utilities could use it.

Mr. HARKIN. Does that make the argument then for Mr. DiGiovacchino?

Mr. JACKSON. No, I am talking about the wind resource data, the energy data that has been accumulated. We have found ourselves that in order to make a useful business, we have got to go out and get it ourselves in a way and form that it would be useful.

Let us turn specifically to the MOD-5. Sure, we were interested in the MOD-5 and we pursued that as an opportunity. The reasons for our not getting that contract there is no point in debating here. Be it though a couple of factors. First of all, having lost that contract we went on our own to do what we planned to do under the MOD-5 program and we have made a very substantial investment. We have put in place the technology that was not there at the time that we competed for that competition and we are convinced that our machines and derivatives—I do not mean the exact machine that is going to be in Medicine Bow—but like there is a 727-100, there is a 727-200, our family of machines, and some day we will have one with a very large rotor also are, today, commercially marketable with once having established a reliability base.

The final point that I would like to make is that marketplace circumstances change dramatically from the time of testimony, which was September 1979, in terms of our whole perception of oil price, the impact of legislation, energy tax credits, and all those things which have made possible the creation of a potential market.

Mr. HARKIN. It seems to me that the change in marketplace works against your argument.

We now have an oil glut, we are not certain as to what the price of oil is going to be, we may have more natural gas than we know what to do with—nobody seems to really know the answer to that question. So, if anything, to prove the reliability, the commercial

reliability, of these wind machines, seems to me to be a proper governmental role at this time. The current energy market cuts against you. If it had gone the other way it would be in your favor.

Mr. JACKSON. The point is that the Government does not come close to doing—to proving the commercial reliability any more than the MOD-2 program has proven the potential of a commercially viable product.

Mr. HARKIN. The MOD-5 program, taken to completion will not?

Mr. JACKSON. I do not believe—my conviction is that it will not.

Mr. HARKIN. Let me ask Mr. DiGiovacchino?

Mr. DIGIOVACCHINO. We, of course, are proponents and supporters of the MOD-5A program. We have examined it critically and we think that the Government program, as structured, is well-defined and will give us the data and information that we need.

Mr. HARKIN. If you complete the MOD-5 program.

Mr. DIGIOVACCHINO. That is correct, sir.

Mr. HARKIN. I guess I do not understand why you are saying that it will not, Mr. Jackson. That is what I do not understand.

Mr. JACKSON. Assuming that the MOD-5, first of all, is a technical success, which I doubt, but assuming it is, then to prove its reliability will require many thousands of hours of operation on each of the machines that are built, operated in the utility environment, to see whether they will, in fact, attain the levels of reliability which have got to be measured in the 90-percent range or higher, in order to make it a commercial product. We are off to do that. We believe we will accomplish that in the mid-1980's with our equipment at private expense.

Mr. HARKIN. Mr. DiGiovacchino, in the previous testimony before the committee you stated, and I am using a quote here, "the state of the art now permits us to design a machine for introduction into commercial practice. It is important to note, however, that large wind turbines are highly immature from a viewpoint of operating experience and data on reliability and availability are not yet developed."

Again, in light of that, do you believe that it is appropriate for the Federal Government to support the MOD-5 wind program beyond the design stage?

Mr. DIGIOVACCHINO. In our testimony last year, and we would now reaffirm that position, we stated our belief that although we have the knowledge and the wherewithall to design a product which has commercial application and to incorporate the appropriate commercial features, we must get this product designed, through the development tests, through the manufacturing, and through the installation and field operation in order to gather the required reliability data. Only at that point could you, in fact, say that you have a machine which is ready to go into commercial service.

Mr. HARKIN. I am going to do this ping-pong act with you two until I get some more information.

Mr. Jackson, on page 10 of your testimony you discuss the technological deficiencies of existing large wind machines, many of which were built with DOE funds. But you do not have any operating experience yet with your large wind system so how can you be certain that they will not exhibit similar deficiencies?

Mr. JACKSON. Obviously we do not have the proof.

Mr. HARKIN. You are just saying that it is going to.

Mr. JACKSON. Let me just say this. We were willing to gamble about $100 million of corporate funds on very large projects based upon our belief in its success without any Government assistance whatsoever. Now, that has got to testify to some conviction and knowledge with the product with which we are dealing.

Our fundamental belief is that the fundamental piece of technology which is causing universal failures of practically every wind turbine that you can point to has been the failure to put in place of the fundamental dynamic analysis understanding of the behaviour of components and how they act within the machine.

Mr. HARKIN. You are saying it is the interaction between the components.

Mr. JACKSON. I am talking about interaction. Now this is something that becomes more and more important and critical as you move toward these lighter, more flexible, potentially much less expensive machines, such as the MOD-2, MOD-5, our machines, et cetera, all of which are basically, what we call soft machines. But there goes with that a complexity of mathematical modeling which we alone have in hand. We have a complete, absolute simulation of all the components that work in this kind of machine. When I say "simulation" I mean the rotor, the shaft, the tower, the generator, all the parts are simulated and are put together against which we throw all the loads which it can experience and we measure how it reacts to the control system which we have in place. This is the fundamental kind of technology that is there in the aircraft industry. It is there in the rotary wing business and it is fundamental to the success of the rotary wing business.

Why is the MOD-2 today experiencing twice the stresses, twice the loads than they anticipated and component lives which are measured in a few months because they do not have in place a simulation, a complete simulation of the equipment. We do. We can go out and simulate the MOD-2 system exactly and produce exactly the kind of results that are being measured on the MOD-2 machines but the other guy cannot and that is the nature of the structural problem and what will affect the lives of all of the components and their reliability. These parts have to last 30 years if they are going to make it—or a reasonably long time period if you are going to have a reasonable operating cost.

Mr. HARKIN. Let me follow this up with two separate questions.

Basically, what you have just said now you also said on page two of your testimony, that "no satisfactory system dynamic analysis techniques have until recently existed for use in configuring advanced, low-cost, large wind machines." However NASA/Lewis has developed very sophisticated load fatigue models for wind systems. Are you including the analytical capabilities developed at NASA/Lewis in that statement and in this statement too.

Mr. JACKSON. Yes.

Mr. HARKIN. What you are saying is that what they have done is not very good?

Mr. JACKSON. I did not say it was not very good. I said it was not adequate.

Mr. HARKIN. I am going to follow that up. In your testimony you said that your company has been actively involved in the development of wind machine design tools. What is the basis for the predicted accuracy of your dynamic analysis design tools and the reasons for the inadequacies in the design tools used in other companies and NASA/Lewis.

Mr. JACKSON. Again, I will, basically repeat——

Mr. HARKIN. It is because of your experience in blades?

Mr. JACKSON. No, sir. United Technolgies' historical product has been rotating machinery and all the rotating machinery, if I set aside the fans and the engines which we also know very well, is helicopter propellors. We have a very deep knowledge and background and understanding of those systems.

Those tools that are available in our design groups were not adequate to produce this wind machine. This is not a simple machine that we are building here one bit. It is a very complex, very sophisticated piece of machinery. We took what we had and it is unique and highly developed within the corporation. Starting about 1975 we worked continuously on this with top talent to bring it to the point today where we do simulate in entirety, as we do our helicopters—the total system. You cannot simulate if you do not have a successful system, particularly in these light, soft systems that we are dealing with. The old rigid systems, the old four-bladed, Dutch system, even the MOD–1 which we had an early involvement with, was basically nothing more than a propellor on a stick. It was very stiff, almost a concrete foundation. The world we are in today is entirely different with these more advanced and potentially lower cost machines.

Mr. HARKIN. And you are saying that your analytical capabilities are much better than NASA's? That is what you have said.

Mr. JACKSON. That is what I am saying. We are competent to do the job and I do not believe there are any others who are.

Mr. HARKIN. Let me get back to General Electric then. What would be the total amount, if we do this, of Federal funding to complete fabrication and testing of one MOD–5 prototype.

Mr. DIGIOVACCHINO. Total Federal and G.E. funding to complete the MOD–5A program after this year is about $22 million. That completes the design and the development, the integration and testing, and installs and operates the prototype.

In our discussions with NASA/Lewis——

Mr. HARKIN. In what year?

Mr. DIGIOVACCHINO. By December of 1984 the machine is built, installed and operating. In our negotiations with NASA/Lewis, the degree of sharing we are discussing is approximately 50/50 of the funds to complete, which is significantly more than the committee asked for in their appropriations message last year. That request was essentially half of the hardware cost, which would have been about $6 or $7 million.

Mr. HARKIN. So you propose going 50/50 with NASA/Lewis.

Mr. DIGIOVACCHINO. It is essentially that.

Mr. HARKIN. How much do you need next year?

Mr. DIGIOVACCHINO. Approximately $15 million of the $22 million total. That includes our share as well as their share.

Mr. HARKIN. Does that include the Boeing prototype?

Mr. DiGiovacchino. That is the MOD-5A program, the General Electric program. All my numbers pertain to the MOD-5A.

[The information follows:]

General Electric Co.,
Washington, D.C., March 23, 1982.

Hon. Don Fuqua,
House of Representatives,
Rayburn House Office Building, Washington, D.C.

Dear Don: The following information is provided as a further clarifaction of the testimony presented by D. J. DiGiovaccino on behalf of the General Electric Company at the Subcommittee hearing on March 17, 1982.

As indicated in the testimony, the funds required to complete the MOD-5A Program after 1982 would be approximately $22-$24M with $15-$16M required in fiscal year 1983 and the balance in fiscal year 1984. Our current negotiations with NASA/DOE include the cost to complete being shared on an approximate 50/50 basis between NASA/DOE and General Electric subject to appropriate terms and conditions. Because of the distribution of tasks wherein the Government would be responsible for design and development test and General Electric would be responsible for the hardware tasks, the Government share would be higher in fiscal year 1983 (between $9-$10M) and lower in 1984 (between $2-$3M) although the overall share of completion costs would remain approximately 50 percent.

Don, I hope this clarification is helpful to you and your staff.

Sincerely,

William H. Patterson.

Mr. Harkin. Just one clarification. That is $15 million in Federal money?

Mr. DiGiovacchino. $15 million represents the total funds required for the MOD-5A next year (1983) while the remaining $7 or $8 million will be for 1984 and beyond. It might be $16 million, I am not sure. The Federal portion would be their share of that $15 million.

Mr. Harkin. $7.5 million?

Mr. DiGiovacchino. More or less.[1]

Mr. Harkin. Do you have a wind machine that can be marketed commercially now at General Electric?

Mr. DiGiovacchino. We do not.

Mr. Harkin. OK. Compared to last year, what is your assessment for the market for wind energy systems compared to last year?

Mr. DiGiovacchino. I think the ultimate market has not changed compared to last year, however the timing of the development of the market has. The experience that we have had with oil prices and the perceived notion that the glut will last for a very long time, is probably going to legislate against the market starting as quickly as it would have based on what we saw last year. But, we believe the total market will still develop and still reach the same level of utilization.

Mr. Harkin. We just heard from Mr. Jackson that United Technologies, I believe, has put $100 million of its own money into this. How much did General Electric put up of its own money?

Mr. DiGiovacchino. At this point in time, General Electric has participated in the Federal program on the program's Federal funding. We are about to put our money into the program because the ground rules have been established.

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[1] Note.—See attached letter to Hon. Don Fuqua. "The Government share would be higher in fiscal year 1983—between $9 and $10 million—and lower in 1984—between $2 and $3 million—although the overall share of completion costs would remain approximately 50 percent."

Mr. HARKIN. You have put none of General Electric's own money into the wind system, not just this model but anything else? Total contributions?

Mr. DIGIOVACCHINO. To the extent of a direct contribution to the development of the machine, the answer is no. But to maintain the organization, the system, the technology and the talent and that sort of thing, it is very difficult to measure.

Mr. HARKIN. What would be General Electric's commitment in this program after the MOD-5 program?

Mr. DIGIOVACCHINO. The level of commitment in the program will have to depend on the results of the program. As I testified, there are significant risks involved. Once the machine is up and operating and we determine that, in fact, it has the capabilities and then, parallel to that, the market is developing in the way we projected, we would be at the point of making that kind of commitment. We could not make that now.

Mr. HARKIN. What I am trying to resolve between you two is this. General Electric seems to be have much more upbeat predictions for the future use and need for these machines. On the other hand United Technologies seems to be more upbeat on its own development of the machine outside of a Federal program. Something does not track here. Mr. Jackson, you say you have put $100 million of your own money into wind machines and you are going your own way on them and you have all these design tool capabilities to analytically design them—you have all this confidence in the machine, but I did not know what you feel the future is for wind energy in the United States.

Mr. JACKSON. I would like to comment on that. I think I would leave the wrong impression if we did not feel that this is a very important potential business market or product for United Technologies. We do believe that it is going to be delayed as Danny just indicated also because of the current economic climate and the perception of oil prices.

As I indicated earlier in my testimony, however, we believe that our machine will, provided reliability is demonstrated to the satisfaction of the utilities, will display a cost of power energy which is competitive with coal and oil alternatives in the Western United States. It will not in many parts of the United States but it will be in the higher wind areas.

Just to try and be very precise with the figures, we put $25 million of our own money into this thing so far.

Mr. HARKIN. Not $100 million?

Mr. JACKSON. We were ready to invest another $100 million in commercial, in the right kind of commercial project which gets us through that kind of reliability demonstration and basically breaks us even.

We are still ready and prepared to do this. It is clearly our plan to do that. I am not going to go into it here in detail, but we are on the course to build the quantity of machines in post concert with a major utility, get the utility to have those hands on the machines to put to bed that reliability question, because the reliability question is just put to bed. There is no question in our minds that we have a very large market for the machines that we have in being and their derivatives.

Mr. VOLKMER. Mr. Chairman?

Mr. HARKIN. Yes, certainly.

Mr. VOLKMER. What is the kilowatt hour output for the WTS-3 and the WTS-4?

Mr. JACKSON. Well, it depends upon the site.

Mr. VOLKMER. Well, let us say you have it in a high wind site?

Mr. JACKSON. In Hawaii, in the north part of Oahu, on the lower intensity ridges, they will run about 13 million kilowatt hours per year and on the high intensity ridges they will run close to 20. That is our existing machine. The derivatives of the machine that we plan to put into production will produce substantially more than that.

Mr. VOLKMER. What are the MOD-5 projections?

Mr. DIGIOVACCHINO. For the MOD-5A specified wind regime which is a moderate wind regime, the output is about 22 million kilowatt hours per year. We have looked at the MOD-5A in a number of applications and locations including the Hawaii site. In the more intense ridges of the Hawaii site, the MOD-5A will produce in excess of 30 million kilowatt hours per year.

Mr. HARKIN. Danny, what kind of corporate commitment do you think that General Electric has to this?

Mr. DIGIOVACCHINO. I think that the commitment to make this investment in the hardware is a commitment that says we believe there is something there and we are willing to continue to support it and find out exactly what it is.

The commitment has not been made and has not been required to be made, that we are going to produce hundreds of these machines on a commercial basis. We have to do the design, we have to prove that the design works, we have to get the reliability and acceptability data and at the same time we have got to let the market develop. As the market develops in parallel, then the commitments will be made.

Mr. VOLKMER. I have one more question. Mr. Jackson, you commented on this before, but I wonder when we are going to get to the point where we have the needed technology foundation. You said that needed machine reliability can never be realized if new engineering designs continue to be formulated on an inadequate technology foundation, the basic situation widespread today.

When are we going to qet to the point where we do not have an inadequate technology foundation?

Mr. JACKSON. Specifically in that, I went on to say that we do. I cannot say when the rest will have it.

Mr. DIGIOVACCHINO. I might also point out that we also believe that in conjunction with the Federal program, we do have the technology base or we would not be ready to put our money into the development.

Mr. VOLKMER. That is all I have on wind.

Can I ask Mr. Germain a question?

Mr. HARKIN. Sure.

Mr. VOLKMER. Will hot dry rock ever be feasible for electrical generation on a cost basis?

Mr. GERMAIN. The goal of our program is to determine whether or not it will be feasible, so for me to answer "yea" or "nay" would probably be——

Mr. VOLKMER. So it is an unknown factor?

Mr. GERMAIN. Privately we have confidence that as the technology evolves it will be technically feasible perhaps at least in special situations if not generally.

Mr. VOLKMER. If we complete the program at least we will have results that will be found in reports 20 or 25 years from now?

Mr. GERMAIN. I hope not that far ahead but yes, in principle.

Mr. HARKIN. I just have one final question, Mr. Lacy, on the Heber project. You said that last year you testified that without continued Federal support the industrial partners would not continue the project on their own. However, EPRI released a study on the reliability aspects of the Heber plant in October. They said it appeared to be capable of higher reliability and availability than other flash units. I am just wondering if circumstances have arisen that maybe indicate that the industrial partners would go ahead on their own.

Mr. LACY. No, I do not see a change on the part of my partners and certainly not my company.

The EPRI study that you referred to was a report on a computer mathematical modeling technique that they have sponsored for taking the design of a plant and exercising it in a computer and based on certain inputs predicting potential availability or reliability.

We are using that technique as a matter of fact to implement the design work as we progress and the work we have seen so far on paper, and that is the important distinction here, on paper, looks like we should be able to achieve very high reliabilities, we still have to demonstrate it in the field as my cohorts to my right have been parroting most of the afternoon. The utilities still have to see the equipment operate in the field.

Mr. HARKIN. Do you have a question?

Mr. STEINWAY. I just have a couple of questions for Mr. Lacy.

The committee has recently heard testimony or has become aware of the fact that DOE would like to work with the partners in the Heber project to complete Federal funding requirements for this project in fiscal year 1982 so that no additional capitalization would be required in fiscal year 1983. Would you support this type of agreement and, if so, according to your estimates, how much Federal funding would be required in this arrangement in fiscal year 1982?

Mr. LACY. We would certainly support it if the funding that we see as being necessary—I am talking additional funding now which I assume would come from reprograming could be made available to the project. We have done a financial analysis and determined that we need approximately $29 million to close the funding circle. This is in addition to the $19 million in 1982 and prior year funding that has already been appropriated.

Mr. STEINWAY. Just one final brief question, Mr. Chairman. What types of problems, if any, have you seen with Federal management authority in undertaking your demonstration project? Do you have any recommendations on ways to help streamline Federal management responsibilities on this project?

Mr. LACY. There have been some problems, some concerns, and really how we might view the prior subject of the buyout, if you

will, ties into Government involvement or DOE involvement in the management of the project.

There are a number of areas where the Government is in a position to adversely impact costs on the project, primarily through decisions or lack of decisions that impact the schedule.

Bear in mind that San Diego, the private sector, is liable for all of the cost overruns on the project. There is a lid on Government cost exposure. Let me give you an example. I need to get prior consent for any cost plus contract I enter into, it does not matter how big it is—it could be $1 or $100 million—and I have to get prior consent for any fixed price contract over $25,000. If you look at the procurements that we are making on this project, and I will probably be making something like 48 over the next few months, every single procurement has to be blessed by DOE. I am not implying that I want to skirt the procurement regulations. I cannot do that internally. The concern I have is submitting all of these to DOE for consent. By doing that and letting them take control of my schedule when, in turn, San Diego is responsible for any cost overruns that might result.

Mr. STEINWAY. Thank you, Mr. Chairman.

Mr. HARKIN. Mr. Volkmer?

Mr. VOLKMER. Mr. Lacy, what would be the minimum Government funding that you could get by with in fiscal year 1983?

Mr. LACY. We are on 1983 funding now. I want to make sure that——

Mr. VOLKMER. You just got finished with 1982. You just got paid for 1982 and upgraded and put in additional money——

Mr. LACY. Approximately $23 million.

Mr. VOLKMER. That is the minimum?

Mr. LACY. Yes.

Mr. VOLKMER. In other words if you got $10 million you would shut down?

Mr. LACY. Yes; we would shut down.

Mr. HARKIN. Anything else?

[No response.]

Well, thank you all very much. It has been an interesting panel. The Subcommittee on Energy Development and Applications will stand adjourned until 2 p.m. tomorrow in room 2318 when we will cover fossil energy.

[Whereupon the meeting was ajourned at 4:35 p.m. to reconvene at 2 p.m., March 18, 1982.]

Department of Energy
Washington, D.C. 20585

April 12, 1982

Honorable Don Fuqua
Chairman, Subcommittee on Energy
Development and Applications
Committee on Science and Technology
Washington, D.C. 20515

Dear Mr. Chairman:

Enclosed are the answers to questions submitted by the Science and Technology Subcommittee on Energy Development and Applications subsequent to the March 9, 1982, hearing concerning the authorization for conservation and renewables. Joseph J. Tribble, Assistant Secretary, was the witness for the Department of Energy.

If you have any questions, please call Ingrid Nelson or Tom Pretorius of my staff on 252-4277. They will be happy to assist you.

Sincerely,

Thomas N. Pretorius

for Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosures

cc: Ms. Martha Krebs
Staff Director
Subcommittee on Energy
Development and Applications

QUESTIONS AND ANSWERS SUBMITTED BY DOE FOR THE RECORD

1. Q. The President's initial budget for FY 1982 requested 262 positions in conservation to support a program of $195 million. At the end of FY 1981, following the September 25, 1981, RIF, the conservation programs had about 350 people on board, including state and local programs and field offices. It was testified by Dr. Savitz that this number would be adequate to run the FY 1982 programs at the levels ultimately appropriated by Congress, $384 million. Yet the budget books for FY 1983 on p. 12 show a personnel level of 105 for FY 1982. Please explain why this level is so much lower than previous figures. Can the full FY 1982 appropriated conservation program be run with a staff of 105? If not, why does this number appear in the budget books?

   A. The manpower level of 105 for FY 1982 in the President's budget request represents the manpower target for the last work day of FY 1982. This is not an average manpower level or a manpower ceiling for FY 1982. The conservation and state and local programs, including staff in the field, started FY 1982 with 335 permanent staff on board. This number will reach the level of 105 via attrition and, if necessary, after appropriate Congressional action reduction-in-force actions will be planned.

2. Q. In solar we understand the FY 1982 ceiling was 96, and the number on board as of October 1, 1981, was 138. Yet the FY 1983 budget books show 59 staff on board at the close of FY 1982. Why is the number so low? Can the programs be managed at the Congressionally appropriated level with 59 staff?

   A. The solar manpower level of 59 on board at the close of FY 1982 represents the manpower target for the last work day of FY 1982. This number is considered adequate to implement the FY 1983 budget request if approved by Congress.

3. Q. When will the reduction-in-force take place that reduces the CE programs to the end-of-1982 levels shown in the FY 1983 budget books? How many personnel will be RIF'd?

A. The timing of any reduction-in-force action is dependent upon Congressional action on the FY 1983 budget. Based on our current rates of attrition, we anticipate a RIF will be needed to meet FY 1983 staffing levels, including field activities for the grants programs. But, the exact number is yet to be determined. However, as we have said, we do not at this time anticipate actually executing this RIF until Congress has acted on the FY 1983 budget.

4. Q. What measures is the Administration taking to ensure that sufficient personnel remain to administer the CE programs if Congress chooses to restore FY 1983 funding to a level close to the FY 1982 appropriations.

A. As vacancies occur in CE critical program areas, i.e., programs not scheduled for closeout in FY 1982, we intend to transfer personnel from our lower-priority activities. This will permit us to train our existing work force in the knowledge, skills, and responsibilities of our critical programs and retain their institutional knowledge of the lower-priority activities. Where critical vacancies have occurred, CE has also elected to reemploy on a temporary basis approximately 20 individuals who were terminated during the September 1981 RIF. This has permitted us to maintain an increased degree of continuity in all program operations, without compromising the availability of manpower resource levels. By using the temporary appointment option, CE has increased its capacity to adjust allocations for a specific program area with very little advance notice.

5. Q. Please explain the criteria used in carrying out the reduction-in-force in the Senior Executive Service in CE as detailed in Assistant Secretary Tribble's memorandum of January 13, 1932, to the Chairman of the Executive Personnel Board. How was it decided which individuals would be riffed and which retained? Does the phrase "curtailment of function" mean the position is being terminated? If so, who will direct the divisions of "resource management," "consumer products," and "energy storage" whose directors all are scheduled to the riffed?

A. The CE Executive Resource Allocation Voucher (CE-82-002), issued by the Department of Energy on December 4, 1981, established our SES (Senior Executive Service) position ceiling at 25 for FY 1982. Post-voucher adjustments increased the SES ceiling to 26. In response to this allocation, the Assistant Secretary and his senior management reviewed FY 1981 SES allocations, to determine where tasks and/or reporting relationships could be combined or restructured to comply with assigned SES allocations and still meet all prescribed program responsibilities. The policy and procedures for conducting an SES RIF have been defined in DOE Order 3305.2 "Senior Executive Service-Employment," dated August 11, 1981. The RIF process will be administered by the Assistant Secretary for Management and Administration and will be implemented on a Department-wide basis.

The phrase "curtailment of function" refers to a circumstance in which a program is scheduled under the President's budget for "close-out" in FY 1982. As with any "close-out" or "phase-down" effort, the individuals associated with the targeted function are terminated or shifted to new duties and responsibilities. Any functional requirements that will be retained in the program areas of "resource management," "consumer products," and "energy storage" will be supervised by knowledgeable line managers at lower grade levels and/or by streamlining reporting requirements.

6. Q. Explain, in detail, how the activities carried out in the Building Systems program constitute "technology development undertaken for the purposes of accelerating the introduction of new technologies." Specifically, please explain how the objectives and activities listed under each FY 1982 subprogram activity in the briefing charts prepared by the subcommittee staff constitute an acceleration of the introduction of new technologies.

A.

Excerpts From FY 1982 Briefing Charts	Role in Accelerating the Introduction of New Technologies
Wall & Roof Systems	
Objective: To understand how the non-steady-state transfer of heat, moisture, and air through the building shell performs under actual conditions.	The present method of estimating the performance of roof and wall sections is based on the "sandwich" method where the performance of each layer is assigned a value and the performance of the wall is assumed to be the sum of these individual values. There is some evidence this is an inaccurate way to estimate actual wall performance. The research will increase the technical understanding of wall performance. Builders, designers, and manufacturers can use this information to develop new wall materials, designs, and building practices.
Activity: Complete roofing field study and initiate roof model. Continue testing and analysis on New Mexico and NBS test cells.	See above. In addition, the New Mexico and NBS test cells will provide more accurate information on the affect of mass on building design. Findings from the research provide a basis for private development of materials with greater mass for several types of buildings.
Complete NBS calibrated hot box.	See above. In addition, the calibrated hot box will provide more accurate measurements than available

	previously on the thermal performance of whole wall segments. Such measurements provide basic information for use developing new wall systems.
Thermal Insulation	
Objective: Develop new and improved test procedures and instruments to determine performance of insulating materials.	See above. In addition, the current method for estimating the performance of insulating materials is to test small (1 inch) thickness, and then multiplying these insulating values times the thickness of the insulation. The evidence shows this exaggerates the insulating qualities of thick insulation installations. More accurate measuring devices will provide a basis for the development of insulations that performs effectively at thicker levels.
Activity: Complete development of permanency test for celloulose.	There were questions as to the potential problem of separation of fire retardent chemicals at high temperatures, varying moisture conditions or combinations there of. The findings of this research will put those life/safety fears to rest or permit the development of chemicals that respond appropriately to the problem.
Activity: Continue development of an analytical model of thermal insulation heat transfer.	See above. In addition, this development will incorporate the ability to model heat transfer more accurately, based on the above research. It will provide a basis for the development of new technologies to respond to these findings and permit the performance of these technologies to be more accurately modeled prior to costly full scale tests and product development.

Windows and Daylighting

Objective: To develop an understanding of the complex flow of energy through windows and its interaction with the building structure. This includes the use of natural daylighting and window management and making this research available to architects and engineers.	The present level of understanding of how to design buildings to take advantage of the complex interact heat loss, gain and daylighting substitution for artifical lighting is far behind our understanding of heat transfer through walls. Current calculation methods are cumbersome and uncertain. Designers, manufacturers and builders can use this information to develop new window designs and products and new daylighting applications and building practices.
Activity: Complete addition of 5 new thermal modeling capabilities to our window computer model, THERM, and DOE-2.	See above. In addition, these modeling techniques will permit more accurate predictions on how one might design improved window products and more appropriately apply existing products in more effective ways. They will permit the large number of designers not now addressing the energy issues of windows and daylighting to do so.
Activity: Complete first Mobile Window Thermal Test module, conduct field calibration and validation tests.	See above. In addition, this facility will provide accurate field data under controlled conditions to provide accurate information on windows. This information is needed to improve calculation methods and the understanding of how window designs can be modified and improved. This will provide a basis for private development of glazing materials and window products.

Complete analysis of the net annual performance of windows with multiglazing materials, operable insulating materials, and fixed shading systems.	See above. This will accelerate the technologies involved in the tests by providing accurate data of annual performance and assist in the development of improved technologies in areas not effectively addressed by these technologies.
Infiltration	
Objective: To understand the flow of air through holes in buildings; to develop design and retrofit techniques to reduce the air flow; to develop test methods and models to determine infiltration rates in buildings.	Infiltration in buildings has been found to be a much more significant factor in building energy use than had been assumed in our building design analyses. Infiltration will assist the improved understanding of the private sector in developing technologies to respond to the problem. This development and introduction should be accelerated by increasing this understanding and developing accurate test methods and models with which to evaluate the new developments.
Activity: Develop new long-term averaging instrumentation, and measure infiltration rates into high-rise office buildings in collaboration with International Energy Agency and U.S. utilities.	See above. In addition, while considerable progress has been made in residential buildings, it is believed that additional infiltration factors apply to high-rise buildings. Instrumentation and measurement in high-rise buildings can be expected to have a similar effect on technology development to that on smaller buildings.
Activity: Complete residential infiltration model, validating it against data base of measured values.	See above. In addition, this model will improve the building designer's understanding of the problem and his confidence in predicting the results of incorporating new technologies solutions in new and retrofitted buildings.

Estimating Methods

Objective: To develop mathematical models for estimating the heat transfer through the building envelope and of the peakload and partload performance of HVAC equipment; to understand the interactions between HVAC systems, controls and the building envelope and understand the effect of climate on building energy use; to develop strategies which optimize retrofit selection.	The ability to understand the complex interaction of energy phenomena in whole buildings has improved significantly in the past 5 years. This has lead to the development of new approaches to building design and retrofit. This improved understanding can be expected to continue to foster new technological solutions as more designers, manufacturers and builders catch-up on these developments and apply these technologies.
Activity: Continue DOE-2 program development, documentation, and complete second phase validation.	See above. In addition, it is necessary for the private sector to be able to access and use the models developed to analyze new concepts and test hypotheses, in order to develop new technologies. Confidence in the validity of the model should speed acceptability and use.
Activity: Continue research on simplified methods for residential buildings.	See above. In addition, the technology under development will be much more readily and widely accepted by designers and builders if they can verify the effect these technologies will have on their individual small building design. Simplified models, that accurately reflect the recent understanding larger models have given us, do not yet exist.

7. Q. We understand the Office of Industrial Programs now routinely asks its contractors whether they would carry out their research without Federal funds. Please provide, for the record, any correspondence from industrial program contractors that discusses their plans for the contingency of termination of DOE funding and their general perceptions of the usefulness of the industrial energy conservation program.

A. A collection of such letters is attached.

Rainier Engineering

4 February 1982 DOE:MJS:82/2

Mr. Jerome F. Collins
Waste Products Utilization Branch
CE 121.2
Department of Energy
Forrestal Building
Washington, D.C. 20585

Dear Mr. Collins:

This letter is in response to your question regarding the likelihood of the private sector picking up the funding of the research presently being conducted on the recovery of ethylene glycol from used antifreeze.

It is my opinion that at this stage of the project the research would not be continued if funding had to be supplied by the private sector. While this project is very appealing from an overall energy savings standpoint, it is one which will need government funding to support the research until it is proven that ethylene glycol recovery is both environmentally sound and economically practical. A major reason for this opinion is that it is common practice today to dump used antifreeze into the sewer or storm drain. Disposal of used antifreeze does not present a problem to individuals or to service stations or other businesses which handle the material. Because disposal of used antifreeze is not a problem, the amount of this material available for recycle is unknown. The amount available is a major variable in the economic feasibility analysis.

I doubt that the private sector will undertake a study of this nature which deals with the disposal of a substance which is not currently regulated when it has to deal with environmental problems associated with the disposal of other materials which are regulated.

It is important that the government funding of this research be continued until the fundamental environmental and economic questions have been answered. Once the process has been shown to be economically feasible, I am confident that the private sector would proceed to fund and operate plants to recover the ethylene glycol.

Sincerely,

Michael J. Strand

Michael J. Strand, Ph.D.
President

MJS:tk

1518 Northeast 143rd Street • Seattle, Washington 98125 • (206) 365-0761

Manville Corporation
Ken-Caryl Ranch
Denver, Colorado 80217
303 978-2000

Manville

November 16, 1981

Mr. Jerome Collins
US Department of Energy
Office of Industrial Energy Conservation Programs
Forrestal Building
Washington, DC 20585

Dear Jerry:

When we discussed our unsolicited proposal "Recovery and Reuse of Asphalt Roofing Waste", you asked me to provide you with some additional background information regarding the possibility of industry doing the study without DoE support. You also wanted some indication whether the Asphalt Roofing Manufacturers Association (ARMA) would help in disseminating the information from the study.

Let's take the second item first. I have talked with Richard D. Snyder, the Executive Vice President of ARMA and he has indicated that his organization would be very pleased to distribute results of the study to the members. Since this organization has as members most of the asphalt roofing manufacturers in the country and have many active committees, this will provide DoE an excellent means of letting the industry know about the progress and results of the study. Both written reports and verbal presentations could be made.

The other question you asked is why a company such as Manville would not undertake the study on its own. The following four reasons indicate the problem of industry doing this study:

1. The research is long-range by industry strandards and very little long-range research has historically been done by this industry. Commodity business such as asphalt roofing cannot support long-range research.

2. The cost to complete this project is too high relative to the R&D budgets of roofing manufacturers and the risk is too great. Firms in this industry historically have limited R&D to projects with a very high probability of success.

Mr. Jerome Collins

3. The roofing business, like housing, is in a severe and long slump with factories being closed and profits critically reduced or non-existent. In fact, Bird & Sons recently reported a 9-month loss of about $15,000,000. Few, if any, manufacturers are making a profit.

4. There are few secrets in the asphalt roofing industry. No firm is going to step out on their own and do this study on their own as the results would soon leak to a competitor. There are few, if any, advantages of being first. The advantages of lead time are markedly overweighed by the cost of the R&D plus the added costs of first trials. So everyone wants to be a follower. Without a leader, there is nothing to follow.

Thus, DoE funding can provide the incentive and funding for the project to move. It will not happen without DoE funding. We urge your support.

Very truly yours,

Carl Vander Linden

Dr. C. R. Vander Linden
Director of R&D
Contracts and Applied Technology

mad

CENTER FOR POLICY ALTERNATIVES

CAMBRIDGE, MASSACHUSETTS 02139

E40-245

(617)253-1666
February 2, 1982

Dr. Jerome Collins
Department of Energy
Office of Industrial Programs (CS-40)
1000 Independence Avenue
Washington, D.C. 20585

Reference: Institutional Agreement Ex-76-A-01-2295
Task Order No. 53 (Remanufacturing)

Dear Jerry,

This letter is in response to your recent request for an opinion on the consequences of curtailment of our present remanufacturing study and a judgement on the likelihood of the private sector picking up and utilizing our research results at this present stage of development. The latter part of your question is particularly pertinent in this instance, because our project is structured toward the transfer of our knowledge to industry.

As you know, we have assessed the energy savings possible through remanufacturing, and have found a 5-to-1 energy recapture ratio. This means that every kilowatt hour of energy expended in remanufacturing saves five kilowatt hours of energy embodied in discarded products. If only 5% of remanufacturable products were remanufactured each year, the dollar value of energy savings would be in excess of $300 million (1976 values).

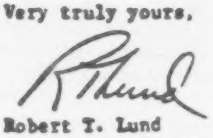
Our project has set about to demonstrate analytically that such potential energy savings can be accomplished, and to develop technological and managerial insights for those in the private sector who can increase the rate of remanufacturing being done in the U.S.

We have conducted a number of studies of technology transfer at the Center for Policy Alternatives. I have personally conducted two in the

past six years. Under the very best of circumstances, university-to-industry technology transfer is difficult. It becomes impossible, if the information to be transferred is still in an incomplete, amorphous state. Before a firm can be convinced to put aside its normal reluctance to launch any sort of new venture, the proposition must be reduced toconcrete terms fitting the firm's, economic and technical frame of reference. This particularly true for remanufacturing, which is an unconventional form of business activity.

Our project is at that critical point where we are integrating what we have learned about the technology, economics and management practices of remanufacturing into practical guidelines for industrial application. To curtail the project at this juncture would mean the elimination of this essential step in technology transfer, and it would also mean the abandonment of our search for specific firms who are willing to establish a remanufacturing venture on the basis of these guidelines. When the project is finished later this year, we should have accomplished our goal of technology transfer to private industry. If terminated now, this will not be accomplished, and a major part of the useful insights we have gained during our three-year project would be lost.

Very truly yours,



Robert T. Lund
Assistant Director

RTL/kab

ARMCO INC.
GENERAL OFFICES • MIDDLETOWN, OHIO 45043

RESEARCH & TECHNOLOGY
L. C. LONG
DIRECTOR
PROCESS RESEARCH

February 3, 1982

Mr. James Fulton
Department of Energy
Forrestal Building - CE 121.3
Room 6G090
1000 Independence Avenue
Washington, DC 20585

Dear Jim:

Dr. Norman Robins has indicated to me that we are once more in a time when an expression of support for the PLAIC work is timely.

As you well know, I have been critical of some aspects of that work. I think that an honest poll of all the steel industry advisory members would show that each of us is critical of some particular aspect of it, because each of us has different needs--different areas where we have progressed on our own. Nonetheless, I believe that the work done at Purdue, overall, will be of value to not only the steel industry, but to other large manufacturing industries in this country.

I do not mean to imply that we are likely to get finished packages out of this project. This has never been my personal expectation or experience. Nonetheless, out of this project as a whole have come valuable developments which have allowed us to go forward on our own and to develop significant applications in our plants. The most outstanding example of this, of course, is our ingot processing system.

The key to the success of our ingot processing syster is unquestionably our ingot thermal model which uses easily observed and recorded input data and can predict with demonstrated accuracy the thermal state of an ingot at any stage in its career from teeming to rolling.

Now our ingot processing system is far more complex than that and involves many logistic controls. Nonetheless, it is the model which is the key to its success and although that model is an Armco development, it evolved from work that we originally supported and cooperated with in the original steel industry project.

Our overall energy saving from the IP systems has been quite significant in direct conservation and we now are beginning to compound that by truly innovative methods made possible by our ability to predict and control.

In addition to ingot processing, we have taken the output of other parts of this study and applied them either to specific jobs in the plant or to our own needs for study of our processes and material flow.

At the present time, our blast furnace engineers are working very closely with the Purdue project and to bring along the blast furnace model that is being produced there. We anticipate that, again, this work will provide a starting point for us to go on to our own blast furnace simulation, and ultimately, on-line control model. We do not anticipate that we will be able to directly use the product of the Purdue program.

In all, we see this program as producing the valuable, fundamental work which is the function of a university. At the same time, it provides a dialogue between the university and industrial worlds, provides insight into each other's problems, and is a source of competent workers for industry.

We believe, even in this era of reduced federal spending, that this project is worthy of support.

Sincerely,

L C Yonn

Corporate Director
Process Research

LCL:slm

cc: W. A. Robins
T. J. Williams

National-Standard

Corporate Headquarters

July 6, 1981

Mr. George Daniello
D.O.E. Office of Industrial Programs
Forrestal Building - Room 2H-085
1000 Independence Avenue S.W.
Washington, D.C. 02585

Re: N-S Co./D.O.E. Cooperative Agreement
No. DE-F007-80ID12163

Dear Mr. Daniello:

In accordance with your request we wish to respond to several questions that were raised with respect to the above referenced project.

Initially we believe it should be pointed out that the D.O.E. solicited contract proposals inviting the private sector to enter into a cooperative agreement with the Department to develop a technology of waste tires into an energy by-product. National-Standard Company responded to such solicitation for two reasons: One, because we felt that we had as much expertise in this area as any other possible submitter and secondly, that the amount of money already expended on waste tire disposal prohibited further capital outlay without third party participation. Additionally, the support and assistance of the D.O.E. was key in our determination to submit our proposal.

While it is our belief that the system will result in a new product line which will benefit the Company and the economy, the prospect of failure is present in this research and development effort as well as in the greater majority of other programs dealing with new products or services. In view of our past experience in this area, further research and development work by the Company without the Department of Energy funding would be unwarranted in view of the risk involved.

We are continuing in our efforts toward realization of a successful project and we look forward to the Department of Energy's continued support and assistance.

Very truly yours,

G. H. Frieling, Jr.
President and

LI·CON, Inc. (LIQUID CONDITIONERS)
P. O. BOX 10717 • PENSACOLA, FLORIDA 32504 • TEL. 904 / 477-0284

June 25, 1981

Dr. Jerome F. Collins
U.S. Dept. of Energy M/SZH085
CS40, Forrestal Building
Washington, D.C. 20585

Dear Dr. Collins,

With reference to our telephone conversation yesterday, I appreciate the opportunity to express my thoughts as to the importance of the role of the Federal Government in providing financial assistance for Research & Development projects. There are many reasons why this is necessary if our country is to maintain its leadership in innovative ideas. I would like to enumerate a few that come to mind as President and Chief Engineer of a small business.

1) In these days of high interest rates it is almost impossible to attract venture capital for high risk R&D projects. If you do, it usually involves turning over control of the business to someone only interested in a quick profit. The engineering control then suffers alarmingly to a point where the project, no matter how good, can be doomed to failure.

2) For a considerable number of years, I worked in R&D for AMF Inc. When the founder, Morehead Patterson was alive, innovative ideas were encouraged and nurtured. Now, the typical conglomerate will usually only entertain ideas germain to their business units. They prefer to let entrepreneurs take the risks and then try to buy them out if they generate a highly profitable marketable item.

3) The small businessman today has to rely on the Federal Government to have a staff of engineers who can evaluate his proposal and where warranted have it funded, and brought to fruition. This, in my opinion, is the only way we can reduce new ideas to practice and benefit mankind.

4) In today's marketplace the risk of failure is disasterous and many good ideas are being stifled. Even a small failure can lead to premature bankruptcy in these troubled times.

5) Simply getting someone to try something new is extremely difficult. The Federal Government has to be the guinea pig in many instances, but the people in the long run

benefit from spin-offs as evidenced by LI-CON's existing contract.

6) The small businessman is, was and shall continue to be the backbone of America, but the only way he can stand on his own against ever enlarging conglomerates is with Federal assistance in such areas as R&D.

Let me say simply in closing, that without the Federal Government's assistance in LI-CON's R&D ventures, I would wile away my time in an easy chair collecting Social Security.

Yours very truly,

LI-CON, INC.

W. R. Williamson, P.E.
President

WRW:emw

ALUMINUM COMPANY OF AMERICA
ALCOA TECHNICAL CENTER
ALCOA CENTER, PA 15069
(412) 337-[illegible]

1982 February 11

Dr. Michael B. McNeil
U. S. Department of Energy
Forrestal Building, Room 2E075
Mail Stop 2E086
Washington, DC 20585

Dear Dr. McNeil:

Subject: Contract DE-AC01-77CS-40079

Modification M017 establishes 1982 February 28 as the completion date for the subject contract. As you know, experimental work was concluded in 1981 and efforts over the past several months have been exclusively devoted to analyzing data and preparing the final report. We anticipate receiving acceptance of the draft report from Government reviewers in time to issue the final report by February 28. Having done so, Alcoa has no immediate plan to continue work on this program. However, we shall continue to monitor emerging technology which could warrant reconsideration of in-house activity. Obviously, any renewed interest by Alcoa would reflect a management decision that additional R&D expenditures would likely result in a process of commercial value. Presumably, the Government would also be receptive to future relationships with industry which would encourage the implementation of direct reduction technology.

As Noel Jarrett has stated to you and others in the DOE many times, the mutual decision to conclude work on this contract does not mean that Alcoa has forever abandoned the idea of being able to reduce aluminum by some direct process. Granted the members of the project team who have worked on this contract will be assigned to other R&D projects in March of this year. This does not mean that they or others would not ever be called upon to further explore or develop a direct reduction process. Alcoa already has a significant investment in this technology and R&D management would surely like to see it contribute to the good of the Corporation.

Hopefully these comments will answer your question of 1982 Feburary 05 concerning Alcoa's proposed program on direct reduction after 1982 February 27. If further clarification is needed, please let me know.

Yours very truly,

D. Jack George
Manager, R&D Contracts
Technology Marketing Division
Alcoa Laboratories

DJG:cjc

LI·CON, Inc. (LIQUID CONDITIONERS)
P. O. BOX 10717 • PENSACOLA, FLORIDA 32504 • TEL. 904/477-0334
477-0198

January 27th 1982

4406 Mahan Rd
Silver Spring, Md 20906

Mr. Stuart Natof
Office of Industrial Programs
Department of Energy
Washington, DC 20585

Contract Funding

Dear Stu:

There are reports circulating that the Department may decide that contractors should assume the remaining costs for their government funded R&D projects despite the facts that funds have already been committed by DOE. For a small business contractor, such as we are, this decision would be disastrous. Most small business have neither the financial resources nor the cash flow to assume whatever the remaining costs are and the contract would have to be terminated immediately. The results would be an unconscienceable waste of the taxpayer's money already spent and very likely the Department would be guilty of violating contract terms.

LICON is now in the final stages of our R&D effort to develop an energy efficient system for industrial aqueous wastes treatment. To stop now means the waste of over $200,000. We simply could not pick up the needed remaining costs to complete the development and we might be in a serious legal bind with our industrial sponsor with whom we have signed agreements. He has already made committments to the project.

I fail to see any advantage, financial or otherwise, to the Government to cause small business firms to assume or try to assume the remaining development costs. I think the consequential legal problems are too complex to consider.

Renegotiating our contract with DOE cannot be a possibility since we fully stated condition and financial abilities at the very beginning.

Sincerely,

Edgar A. Gadwallader PE
LICON Washington representative.

dd: Mr. W.R. Williamson President LICON Pensacola

Westinghouse Electric Corporation

Power Generation

Jack R Barrett
General Manager
Combustion Turbine Systems Division

Box 291
Concordville Pennsylvania 19331

January 5, 1982

U.S. Department of Energy
Office of Conservation & Solar
Energy Industrial Programs
1000 Independence Avenue, SW
Room 6G-056
Washington, D.C. 20585

ATTENTION: Mr. J. Eustis

Dear Mr. Eustis:

Subject: Unsolicited Proposal - "A Coal-Fired Cogeneration Project"

This is in reference to our proposal of July 15, 1981 entitled "Phase Zero - Generic Studies of Advance Fluidized Bed Air Heater Technology." Westinghouse would like to elaborate on the need for Department of Energy participation within this program.

AFB steam generation technology is considered generally to be near commercialization. However, AFB air heater technology is of higher risk and longer term development nature. For AFB air heater technology to become commercial within the utility/industrial sectors, it must be accepted on its technical merit and, even more importantly, on its economic merit.

Technology acceptance by the private sector depends greatly on their need for it and their willingness to accept the associated risk. Advanced coal burning concepts such as the AFB air heater will require a substantial cost of electricity incentive to even be considered. It is our opinion that AFB air heater technology can offer higher efficiency at a lower cost power generation over conventional coal fired steam and AFB steam generation systems.

The statement of work defined within our proposal would assist in evaluating the AFB air heater system and economic option available for consideration by the private sector. At present, the market potential for AFB systems does not justify Corporate expenditures to pursue the proposed program without DOE participation. The role of DOE is clearly applicable during Phase Zero evaluation of the AFB air heater technology concepts and economic feasibility since the development and commercialization will totally be undertaken by the private sector.

Without the DOE participation, I would be reluctant to commit resources to this program. Although we consider the technology to have beneficial long term potential, the technology and market risks are too significant for us to go it alone.

We, therefore, respectfully request that you consider our views on Government participation with our proposal.

Very truly yours,

Jack L. Barrett es

PROCEDYNE
CORP.

Attn: Mr. Bruce Cranford

The participation of the U.S. Department of Energy by sharing the technical risk with private industry made the start of the program possible. This participation has resulted in a successful large scale demonstration plant to prove technical feasibility which in turn resulted in the first commercial plant in this country converting waste atactic plastic to fuel oil. It is important to note that private industry provided the capital for this first commercial plant with the U.S. Department of Energy sharing the technical risk.

The feasibility of converting waste plastic to fuel oil has been demonstrated, however, there is still sufficient technical risk to prevent major movement of private industry into this area. Another major chemical company is well along in considering the use of this process on a commercial scale with still another giving preliminary consideration to the process. The present participation of the U.S. Department of Energy in sharing the technical risk is an important element in maintaining momentum of the program.

In the event that U.S. Department of Energy participation is discontinued, it is predicted that the eventual commercial acceptance of conversion of waste plastics to fuel oil will be delayed significantly, perhaps three or more years. Significant economic benefit to the country will be lost and environmental benefits will be lost. Since this effort by the U.S. Department of Energy is well along toward achieving the benefits that formed the original justification for the program, it would be most unfortunate to discontinue participation at this time.

Yours truly,

Dr. H. Kenneth Staffin
President

HKS/jkb

Manville Corporation
Ken-Caryl Ranch
Denver, Colorado 80217
303 978-2000

Manville

November 16, 1981

Mr. Jerome Collins
US Department of Energy
Office of Industrial Energy Conservation Programs
Forrestal Building
Washington, DC 20585

Dear Jerry:

When we discussed our unsolicited proposal "Recovery and Reuse of Asphalt Roofing Waste", you asked me to provide you with some additional background information regarding the possibility of industry doing the study without DoE support. You also wanted some indication whether the Asphalt Roofing Manufacturers Association (ARMA) would help in disseminating the information from the study.

Let's take the second item first. I have talked with Richard D. Snyder, the Executive Vice President of ARMA and he has indicated that his organization would be very pleased to distribute results of the study to the members. Since this organization has as members most of the asphalt roofing manufacturers in the country and have many active committees, this will provide DoE an excellent means of letting the industry know about the progress and results of the study. Both written reports and verbal presentations could be made.

The other question you asked is why a company such as Manville would not undertake the study on its own. The following four reasons indicate the problem of industry doing this study:

1. The research is long-range by industry strandards and very little long-range research has historically been done by this industry. Commodity business such as asphalt roofing cannot support long-range research.

2. The cost to complete this project is too high relative to the R&D budgets of roofing manufacturers and the risk is too great. Firms in this industry historically have limited R&D to projects with a very high probability of success.

Mr. Jerome Collins

3. The roofing business, like housing, is in a severe and long slump with factories being closed and profits critically reduced or non-existent. In fact, Bird & Sons recently reported a 9-month loss of about $15,000,000. Few, if any, manufacturers are making a profit.

4. There are few secrets in the asphalt roofing industry. No firm is going to step out on their own and do this study on their own as the results would soon leak to a competitor. There are few, if any, advantages of being first. The advantages of lead time are markedly overweighed by the cost of the R&D plus the added costs of first trials. So everyone wants to be a follower. Without a leader, there is nothing to follow.

Thus, DoE funding can provide the incentive and funding for the project to move. It will not happen without DoE funding. We urge your support.

Very truly yours,

Carl Vander Linden

Dr. C. R. Vander Linden
Director of R&D
Contracts and Applied Technology

mad

TECHNICAL ASSISTANCE AND BUSINESS SERVICES TELEX 944478

Gorham International Inc.
ESTABLISHED 1960

GORHAM, MAINE 04038, U.S.A. • TELEPHONE: 207/892-6761 • CABLE ADDRESS: GORHAM • PORTLAND, MAINE
OUR NEW CORPORATE TELEPHONE NUMBER IS 207/892-2210

February 4, 1982

Mr. Stuart Matof
U.S. Department of Energy
Forrestal Building
Mail Code CE 121
Washington, D.C. 20585

Dear Mr. Matof:

I have been reading the papers and watching the news on TV -- the message is clear. Cut - cut - cut out federal programs, grants, projects and now I hear even on-going contracts are being terminated. If contracts like Gorham's IFD project are to be cut off, how are the wide ranging benefits this project will produce going to be accomplished?

The 500 MM Bbls of oil per year which forest residues represents can start replacing oil as soon as five years from now if this project goes full term. But if funding is cut off now who is going to pick up the project and bring it to conclusion?

Before Gorham ever asked for D.O.E. support we sent proposals to all major pulp and paper companies, engine manufacturers, boiler companies and certain other energy intensive companies. We got a better than average response -- all negative. When asked why support was not available a few were willing to bluntly say, "What's in it for us -- us exclusively. Before we can support a risky research project like drying forest residues in the forest we would have to see an exclusive advantage. Our money cannot support projects that benefit everyone -- they have to benefit us first, most, and hopefully exclusively."

Gorham International would benefit exclusively if it could raise the money to fund this project itself -- but it cannot. The risk is too high for banks to help and Gorham is not a capital intensive business. We have only meager assets on which we could borrow money. Our major asset is brain power and you can't use that at the bank.

The situation is worse now than it was when industrial support was first sought. Gorham has spent what it could on this project already. Industry prospects for support are less bright than when we sought support previously. In my judgement we would stand even less chance of gaining support from industry now. State funds have dried up also. The only people I see that would be interested in converting forest residues into

a form more suited to long distance transport are the Japanese. They are constantly asking for more information about this project. That is not where this fuel and feedstock resource ought to go -- it needs to be used in these United States to help our own energy situation. In a nut shell if Federal money is shut off this project will die.

Well, I have said my piece -- if anybody wants to cut this IFD project off before its benefits can be developed, show this letter and give whoever it is my phone number. I want a fighting chance to say my piece to him -- if it ever comes to that.

Sincerely,

GORHAM INTERNATIONAL INC.

Willard C. Sawyer

Willard C. Sawyer
Director of
Biomass Conversion

WCS/d

MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS 02139

Room 8-409

January 28, 1982

Dr. Michael B. McNeil
U.S. Department of Energy
Forrestal Building, ZH-085
Washington, DC 20585

Dear Dr. McNeil:

In relation to a proposal entitled "Diagnosis of Sources of Current Inefficiency in Industrial Molten Salt Electrolysis Cells by Raman Spectroscopy" which has been submitted to your agency, I should like to add several comments.

First of all, this project seeks to make use of Raman spectroscopy in the analysis of operating industrial electrolysis cells. The proposal describes the sequence of research beginning with the adaptation of a commercial Raman spectrometer for use with a high temperature specimen contained in a window furnace, through testing of magnesium and aluminum electrolyses in chloride melts, culminating in measurements of laboratory scale Hall-type electrolysis of aluminum metal from molten cryolite. With its attention to melt chemistry as monitored by Raman spectroscopy the project attempts to solve an engineering problem through research into the basic science on which electrolytic technology is based. As such, I believe this to be a generic, long term project in keeping with the agency's mission.

Secondly, the point must be made that although the problem of current inefficiency in electrolysis cells is an industrial matter, one cannot presume that industry will undertake such a project in an attempt to solve this problem. In fact, in my conversations with high ranking scientists and managers at companies such as Alcoa, Dow, and Reynolds I have learned two things from these people. First, the successful completion of the work proposed would have a considerable impact on energy conservation throughout the light metals industry. Secondly, without any doubt it can be stated that no metals producer will undertake such a venture in its own research organization. None of these companies has either the facilities (Raman instrumentation) or the personnel. Furthermore, these companies are not about to commit the necessary funds to acquire these research capabilities in today's economic climate.

Thus, I feel that if the Department of Energy decides not to sponsor the proposed work, then it simply will not be done. Certainly, I do not have the resources at hand for such a study. As for potential sponsors

elsewhere, I have made representations to the National Science Foundation, the Office of Basic Energy Sciences at the Department of Energy, the Army Research Office, the Office of Naval Research, the Air Force Office of Scientific Research, and the Bureau of Mines. None of these agencies would sponsor the work, although the proposal repeatedly received favorable ratings in peer review.

In conclusion, I should state that it is in the national interest that a project of this type be supported. In view of the staggering amounts of electrical energy consumed in the electrolytic industries (the figure exceeds 1000 billion kWh/yr or 1 Quad/yr), diagnosis of sources of current inefficiency in industrial cells is more than just an academic exercise. This is particularly true for the proposed technique of investigation which has excellent prospects for adaptation to on-line process control which would conserve considerable energy.

The aluminum industry alone consumes four percent of total generated electrical energy in this country. Hall cells continue to operate at voltages in excess of twice the theoretical requirement. The electrochemical techniques of investigation are well known to the industry. I believe that it is time for a bolder innovative approach to the problem and that Raman spectroscopy is just that.

Yours sincerely,

D.R. Sadoway

Donald R. Sadoway
Assistant Professor
Materials Engineering

DRS:ebs

ARIZONA STATE
UNIVERSITY TEMPE, ARIZONA 85281

COLLEGE OF ENGINEERING AND APPLIED SCIENCES
DEPARTMENT OF CHEMICAL AND BIO ENGINEERING (602) 965-3713

February 4, 1982

Bruce Cranford, Jr.
Program Manager
Office of Industrial Programs
CS-40, U. S. Dept. of Energy
Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Bruce:

I offer the following comments concerning our project, CONVERSION OF CELLULOSIC WASTES TO LIQUID HYDROCARBON FUELS (DOE Contract No. AC02-76CS40202).

1. Cellulosic wastes are a viable source material for contributing to the minimization of waste disposal problems with accompanying generation of fuels and chemical feedstocks.

2. A thermochemical conversion approach is utilized (as opposed to biological routes such as anaerobic digestion or hydrolysis - fermentation). The major advantages are low processing times and the capability to accept multiple feedstocks without significantly altering processing conditions.

3. An indirect liquefaction approach is utilized on the project (gasification followed by liquefaction). This approach offers the major virtue of successful isolation of the oxygenated compounds produced from cellulosic wastes from the hydrocarbon products. Thus if one is interested in producing a high quality transportation fuel such as diesel, jet or gasoline, equivalent to that currently derived from petroleum (and thus compatible with current engine designs and the fuel distribution system), an indirect liquefaction approach appears to be the obvious option.

4. The product emphasis on the project has been a paraffinic transportation fuel equivalent to No. 2 diesel and jet fuels (e.g., kerosene, JP-4, JP-5). Conversion to a high octane gasoline is also possible via existing catalytic reformer technology. However diesel and jet fuel demand is expected to increase enormously in the next twenty years. Thus, quoting Dr. Edward David, Jr. (President of Exxon Research and Engineering Co.), ". . . The result is a historic shift in the pattern of demand for liquid fuels: whereas the nation now consumes about three times more gasoline than jet and diesel fuels, it could be consuming about equal portions by the year 2000." (IGT Gascope, Autumn 1981).

5. Modification of the liquefaction step (catalyst type and operating conditions) offers the possibility of producing alternate products appropriate for market conditions at different locations.

6. Process simplification studies offer the eventual possibility of a portable system that could be moved to alternative feedstock sites.

7. The project is generally recognized as being at the forefront in research to convert biomass type materials to liquid fuels (citations available on request).

8. A large number of students are employed on the project (~20 at present). Thus individuals with advanced training for careers in energy related fields are constantly emerging from the project.

9. The concept of producing high quality liquid fuels from various cellulosic type feedstocks has been demonstrated on the project. The goals of maximizing product yields, production of alternative products, simplification of the process, further testing of alternative feedstocks and scaleup to a larger facility have not yet been achieved. Thus most items on the current and projected work statements fall into the category of high risk, long term research with economic payoff too far off to attract substantial private industry funds at this time.

10. In time of economic downturn (such as presently exists), private industry inevitably cuts the longer term payout projects in which they are involved. Thus a project of this nature dependent on substantial industrial funding (either in-house or external contract) would be subject to large discontinuities with economic cycle fluctuations. This can lead to chaos with regard to rational process research and development.

11. Public domain funding serves a checks and balances role with private industry. Thus, for example, an international oil company might have the incentive to continue with feedstocks of declining availability with shortfalls compensated by increasing prices. Development of alternative supplies and dissemination of information to the public sector thus encourages private industry to address options of long term benefit to the American consumer.

12. An optimal funding approach is to initiate a long term payoff project with public funds and entice industry to participate via dissemination of positive results with the eventual goal of commercial application with total private funding. This project is following this course.

I hope my comments will be of some use. Please let me know if you would like further elaboration.

Yours truly,

James L. Kuester
Principal Investigator
Professor of Engineering

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ST REGIS TECHNICAL CENTER, WEST NYACK, N. Y. 10994

ROBERT L. MYERS
Vice President
Technology

January 22, 1982

Mr. Al Streb
Director, Office of Industrial Programs
M. S. 6G030
U. S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D. C. 20585

Dear Mr. Streb:

St. Regis has had the opportunity and privilege to work with the Office of Industrial Programs on two cost sharing projects directed towards energy conservation in the pulp and paper industry. In each case, St. Regis' senior management saw the need to solicit and accept proportional government support for these R&D efforts.

Both Hydropyrolysis and computer control are technologies in which St. Regis invested considerable R&D funds leading to the development of new approaches to energy conservation. Hydropyrolysis is a new process while computer control would be a new approach applied to existing processes. In both instances the next step in moving these technologies towards full scale utilization required the expenditure of considerable capital monies and R&D funds and carried a high risk, which combined to preclude further work by a single company.

Considering the importance of energy conservation to the national interest, the impact of these technologies, if successful, on national energy consumption and the high risk involved, St. Regis believes it to be prudent for the Federal Government to support these and similar activities.

Furthermore, we will seek continued support by the DOE for the program on energy conservation through computer control. A major portion of this program has the additional advantage of transferability to other industries. We expect, at the end of Phase 1, to provide basic insights into methods for simulating a continuous process manufacturing plant in a computer with the capability to track unit process efficiencies on a day-to-day basis. This technology will provide the means to schedule plant operations in real-time to reduce energy consumption while at the same time meeting production goals.

The potential significance of this work was well documented in our original proposal and I will not repeat it here, except to remark that it appears to me to represent the ideal combination of accomplishing very high energy savings with a shared risk project. The benefits at a single mill such as Monticello alone would justify the project but I am certain that if it is as successful as we anticipate the technology will be adopted very quickly by the entire kraft paper industry representing at least 100 mills in the United States.

We have appreciated the opportunity to work with DOE and hope that we will be able to continue into the next demonstration phases.

Sincerely,

RLM:bls

Robert L. Myers
Vice President
Technology

cc: T. Gross; Ernest Loeb; John Rossmeissl; S. Sobczynski

FLORIDA COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

COOPERATIVE EXTENSION SERVICE
SCHOOL OF FOREST RESOURCES AND CONSERVATION

AGRICULTURAL EXPERIMENT STATIONS
COLLEGE OF AGRICULTURE

REPLY TO: McCarty West
Gainesville, FL 32611

February 15, 1982

Mr. Al Streb, Director
Office of Industrial Programs
Department of Energy
Forrestal Building
Washington, DC 20585

Dear Al:

In a recent telephone conversation with Wanda, she mentioned the need to justify funding related to the Energy Integrated Farm Systems Program. Apparently the question has surfaced regarding whether or not the private sector could or would pick up the support and continue the program without DOE's involvement.

As you know I have had the experience of working with the farm program while on the IPA assignment at DOE in 1977-78. It was clear to me before I took the assignment, and even more clear after working with the farm program, that private industry in the agriculture sector is not capable nor able to carry out research and development in this area.

Except for the large tractor manufacturers such as Deere and Company, International Harvestor, Ford and others, the bulk of the equipment supplied on the farm is from small manufacturers. These small manufacturers and farmer cooperatives are certainly interested in research and development and often participate as best they can given their limited resources and expertise. We often find them cooperating with Land-Grant Universities to carry out research projects.

The traditional manner in which new developments occur in agriculture is generally of the following nature: State and/or federal research funds are provided to the Land-Grant University to develop new technology or practices to eventually be utilized by the farmer. Sometimes both farmers and small agri-business industries cooperate and even provide modest financial support for individual projects. The new developments occur, and the results are published by extension faculty in many non-technical forms such that the farmers can understand and proceed to implement. In the case of new equipment development, such as a new type of vegetable harvester, the design is utilized by a small manufacturer to produce and market the equipment.

The development of the Energy Integrated Farm System program was prompted because there is a genuine future need for farmers to move toward these types of systems. Without the federal funding, these developments would simply not take place. The DOE program staff saw, with input from advisory groups, the need to develop energy integrated farm systems for the future. Participants

(continued)

The Institute of Food and Agricultural Sciences is an Equal Employment Opportunity - Affirmative Action Employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex, or national origin.
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS, STATE OF FLORIDA, IFAS, UNIVERSITY OF FLORIDA U.S. DEPARTMENT OF AGRICULTURE, AND BOARDS OF COUNTY COMMISSIONERS COOPERATING

were invited to prepare proposals to address this research development area. Eight projects were selected that best illustrated farm systems where energy integration was needed and desirable. None of these eight major projects would have been initiated if it were not for the federal assistance.

The projects are all generally now in the crucial development stage, and significant research information will soon be forthcoming. If funding is no longer available to continue these projects, none will ever reach completion. Farmers do not have the capital to risk on experimental systems. They are willing to invest once the concepts have been developed and tested. The small industries with interest in the programs simply do not have the capital to step in and continue the research on the experimental systems.

If the federal money is discontinued at this point, the loss to the public will be substantial and the rather large sum of federal money already spent will essentially be wasted. The federal government not only loses credibility with the agricultural sector but also reduces the confidence for future cooperation. The real benefits from the program will occur in future years. There is a major multiplying effect because the information gathered from the successful projects is quickly and effectively disseminated to farmers throughout the United States through the Cooperative Extension Service.

I can speak more specifically about at least two of the projects. Since I was located at Cornell University when the dairy project was initiated, I know something about the nature of that project. The Cornell project is an excellent example of the cooperation on the part of the University, state government, private industry, a dairy farmer and the federal government. The project would not have been possible without the federal support. If the federal support is taken away the project will likely never be completed. The farmer would be left with a half completed, non-functional system that would never reach its desired potential. There is a real opportunity for great success with this project that could change the future of dairy farming in the United States and move toward energy self-sufficiency on this type farm.

The dairy farmer must depend, at this point, on having the engineering research capability of the university to carry out the project. Without funds this expertise would not be available and the farmer would suffer serious consequences after being willing in the beginning to allow his farm to be used for the development of a complete integrated system.

Another similar project exists at the University of Nebraska. This project has progressed right on schedule and will eventually be an excellent example of an integrated system for a swine and grain farm. Again, if the funding is not available, this project will not be completed as planned. The loss of the information and future development would be most unfortunate. While they have had some help from state funds and private industry, the loss of the federal partner would essentially kill the project.

(continued)

95-882 O—82——37

I admit to some bias in this area, but I firmly believe that the results obtained from the Energy Integrated Farm System program could be the most significant energy development related to agriculture in this century. It would be an absolute shame to lose this potential benefit with the investment that has already taken place.

Sincerely,

Donald R. Price
Assistant Dean

DRP/ld

cc: Ms. Wanda Porterfield

DEPARTMENT OF STATE

Washington, D.C. 20520

BUREAU OF OCEANS AND INTERNATIONAL
ENVIRONMENTAL AND SCIENTIFIC AFFAIRS

November 13, 1981

Dr. Alan M. Wolsky
Special Projects Group
Energy and Environmental Systems Division
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

Dear Dr. Wolsky:

At my request, Martha Strong of the Office of International Energy Programs has forwarded to me several documents in the Argonne series of energy use in various industries. I greatly appreciate your providing these documents to Ms. Strong for the State Department's use. Our Office of Caribbean Affairs has provided them to the Government of Suriname to determine an industrial development strategy consistent with Suriname's energy supply options.

The documents have been extremely useful in these discussions, and we are grateful that you were able to provide them.

Sincerely,

Jean Christoff

Jean Christoff
International Relations Officer
Office of Energy Technology
Cooperation

LI·CON, Inc. (LIQUID CONDITIONERS)
P. O. BOX 10717 • PENSACOLA, FLORIDA 32504 • TEL. 904 / 477-0334

March 25th 1981

The Energy and Water Development Subcommittee

Mr. Chairman and members of the subcommittee:

I am Edgar Cadwallader, a registered chemical engineer, representing a small business firm, LICON of Pensacola, Florida. We engineer and manufacture equipment for saline water conversion, water pollution abatement, and mineral recovery. I am here this afternoon to speak to the committee about energy conservation and its importance to the nation's overall energy policies for energy independence. I am also speaking about the importance of small business firms and how much of the nation's innovative ideas come from them.

About eighteen months ago we entered into a contract with the Alternative Materials Utilization Branch of the Office of Industrial Programs in DOE to design and build energy efficient equipment for treating electroplating wastes. Because the Department of Defense has environmental problems in its electroplating shops, the Navy contributed about half of the funds for this development. We were highly successful for our machines not only solved an environmental problem, it saved energy and recovered expensive and strategic minerals such as chromium. The savings will result in a return of the capital investment in under three years. Our machine is now being installed at the Naval Air Station in Pensacola. As our nation's forces build up, there will be greater need and incentive to conserve energy and recover valuable minerals.

Mr. Chairman, let me emphasize one fact about the Government's R&D programs. There has been entirely too many "studies and reports" which repose on bureaucratic shelves and contribute little to advancing science and engineering. We produced

a machine to which the Government has rights and which in application will return the original investment many times over.

Today, our nation needs innovation and the small business firms across this country supply more than their proportionate share of ideas. However, small businesses do not always have the ready capital to invest. We are not like the DuPonts, the Dow Chemicals, the Exxons with enormous capital reserves. They dont need Government support. But the Government can step in and give qualified support to small businesses and the return to the taxpayer will be many fold.

The development program we have completed for the Department of Energy and the Navy points to an extension of the technology for application in the chemical and the nuclear industries. For this second phase, we have an industrial sponsor besides the military, and of course we wish to continue with DOE under policies promulgated by Public Laws 93-577, 94-163, and 95-580. We are convinced it is the way to continue. The energy factor is at the heart of the entire program.

In the past when our country has found itself in difficult circumstances, it has called on the engineer and the scientist for help. Do you remember the Manhattan program of the 1940s and the space program of the 1960s? Now we have the environmental and energy crises of the 1980s. Once again the government looks to us for help, and again that help is on the way, but dont cut it short when success is abounding. We recognize that budgets must be pared, but there are programs having high benefit-to-cost ratios which promise immediate returns on investment. Why waste the previous investments which have been made? I believe a respectable amount of financial support should continue. I specifically recommend a continuation of the many good programs exemplied by those in the Alternative Materials Utilization Branch of the Office of Industrial Programs. Thank you.

Respectfully submitted by

Edgar A. Cadwallader

Edgar A. Cadwallader, PE LION Representative
4406 Mahan Rd
Silver Spring, Md 20906

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SJ Matas
Director of Research
AB Blockadge Jr
Associate Director of Research
EP Kawasak.
Assistant Director of Research
DS Leckie
Assistant Director of Research

February 5, 1982

Mr. J. C. Fulton
Department of Energy
Forrestal Building
CE 121.3, Room 6G090
1000 Independence Avenue
Washington, D.C. 20585

Dear Mr. Fulton:

Republic Steel Corporation has supported the Purdue Laboratory for Applied Industrial Control (PLAIC) at Purdue University since 1974. Sponsorship has been maintained because of the valuable input which the Corporation is receiving from the Laboratory's meetings and reports in the area of modern process control. Information has proved quite useful in areas of process modelling, process scheduling, and network design, all within the general framework of modern hierarchical control systems.

In order to be competitive in the world, it will be essential that the American steel industry implement hierarchical control systems as a fundamental part of their technological innovation. I believe that this principle applies to the process industries in general. The PLAIC studies give the advantage of providing new, modern control system designs together with evaluations of the relative effectiveness of alternatives. This fresh, new "state-of-the-art" input is very useful for the design and implementation of control systems either for new plants, or for retrofit systems in existing plants. There is a high likelihood of the incorporation of these ideas and designs into useful systems in the steel industry. Naturally applications of these developments will differ from company to company because each company has its own unique state of systems development. In my opinion there is a high likelihood of incorporation of these projects into systems development in many process industries.

At Republic Steel we are at present installing a new "state-of-the-art" soaking pit control system based on PLAIC model development plus other concepts. This high return project will be extended to other plants once the initial "proof-of-concept" demonstration is made. This system will involve not only heating control but also higher level systems involving information transfer and scheduling. Energy savings have already been achieved with a crude manual implementation of PLAIC results.

The existence of the Purdue work has been an advantage not only for Republic but for other companies in the industry who are also known to be involved in soaking pit projects. It should be noted that new work is underway at PLAIC which gives promise of even greater utility for soaking pit control. This is only one example of payback from PLAIC sponsorship. Other examples could be cited, and other steel company sponsors have similar examples, I am sure.

People with specialized education and experience are required to accomplish this high technology work. Such knowledgeable people are sought in a highly competitive market. Process industries compete with manufacturing, communication, and aerospace and defense industries for people with these skills. PLAIC projects provide welcome opportunities for research into long-range optimal designs. The PLAIC studies have the advantage of being generic in the sense that they are not specific to any company and thus are a general source of systems design information which can be applied in various company environments. Since it would be very costly and time-consuming for each company to perform its own research and development in this area (to say nothing of the difficulty of acquiring skilled people), government support for the PLAIC project would provide a most useful application of government resources. With the scarcity of skilled personnel, companies are hard pressed to maintain competent staffs for short-range, immediate applications let alone long-range development.

A further advantage of the PLAIC project to the sponsors is the existence of the Steel Industry Advisory Committee. This committee helps maintain focus on real-world questions. The likelihood of utilization of these studies is much higher with the input of the Advisory Committee than would originate from an academic abstract approach.

I very much appreciate the opportunity to comment on PLAIC. It is hoped that the Department of Energy will agree that the program has much merit and that PLAIC projects will be supported in a tangible fashion.

Very truly yours,

Donald S. Leckie

Donald S. Leckie
Assistant Director of Research

DSL/aw

cc: Professor T. J. Williams
Dr. N. A. Robins

Inland Steel Company
Research Laboratories
3001 East Columbus Drive
East Chicago, Indiana 46312

219 392 8220

Norman A. Robins
Vice President
Research

Inland Steel

February 3, 1982

Mr. J. C. Fulton
Department of Energy
Forrestal Bldg.-CE 121.3, Room 6G090
1000 Independence Avenue
Washington, DC 20585

Dear Jim:

I am writing to inform you that the Inland Steel Company fully supports the proposal being submitted to the Department of Energy by the Purdue Laboratory for Applied Industrial Control (PLAIC) for continued funding of the project entitled "Hierarchy Control for Energy Savings in the Steel Industry."

As you know, this project is being conducted by PLAIC with the full cooperation and support of several major steel companies, including Inland Steel, and equipment suppliers. This cooperation insures that the work done is relevant, and that, when appropriate, results are implemented as they become available. It is significant to note that several of the developed technologies have already been implemented by individual steel companies, when such undertakings proved to be cost-effective for their particular facilities and needs.

With regard to hierarchy control, there is a continuing need to develop technology to retrofit existing U.S. steel plants with hierarchy control systems. However, the cost of such research and development work is sufficiently large, and the benefits are sufficiently diffuse, that it is unlikely that individual companies would undertake such an effort on their own. Even though the cost justification of a hierarchy control system for a U.S. steel mill is a complicated and uncertain undertaking, it is generally accepted that the application of such a system will result in increased productivity, improved yield, and decreased energy consumption. The Japanese have designed and built greenfield steel plants to incorporate hierarchy control concepts; and those plants have demonstrated that hierarchy control is not only technologically feasible, but also economically justified, especially in terms of major energy savings.

The current PLAIC project is the only program we know that would develop the necessary technology required by the domestic steel companies to implement hierarchy control concepts and systems on their existing facilities. Based on PLAIC's past performance and qualifications, Inland strongly recommends that the PLAIC proposal be approved for continued funding by the Department of Energy. The success of this program would result in more efficient operation of the domestic steel plants, and ultimately in significant energy savings in the steel industry. In addition, the program produces much needed technically trained engineers for the steel industry.

Your favorable and timely consideration of the PLAIC proposal will be much appreciated. If I can be of further help to answer any questions you may have on the subject, please do not hesitate to call.

Very truly yours,

Norman A. Robins

NAR/sgr

New York University
A private university in the public service

Graduate School of Business Administration
114 Liberty Street, Room 300
New York, N.Y. 10006
Telephone: (212) 285-6946

Center for Science and Technology Policy
Herbert I. Fusfeld, *Director*

January 28, 1982

Dr. Michael McNeil
Department of Energy
1000 Independence Avenue
Washington, DC 20585

Dear Dr. McNeil:

Comminution was identified as a large consumer of energy in the 1973 National Academy of Science Committee report "Materials Requirements in the Near Term Energy Program." I was a member of that committee and, when I became Chairman of the Energy Council of the National Materials Advisory Board of the National Research Council, I put together a select committee, under the joint sponsorship of DOE, NSF and the Bureau of Mines, to study this matter. I was asked to serve on this committee.

In the spring of 1981 this committee published the National Academy of Sciences report, "Comminution and Energy." Among the highlights of the report were the facts that one billion tons of rock ore and minerals were ground annually in the United States. This grinding consumed one million tons of steel and 32 billion kWh of energy. Most of the grinding methods and devices are archaic and, if only existing technology were applied, 20% of the energy consumption could be saved, amounting to $160 million/year. In addition, there are strong indications that with further research 50% of the energy could be saved. The report called attention to past neglect by government funding agencies which had not recognized either the enormous aggregate energy consumption of comminution or the potential for improvement.

With the publication of this report, federal agencies, particularly DOE, are rapidly turning their attention to this field. Research is not inexpensive, however. Before a laboratory finding can be introduced to a mill costing hundreds of millions of dollars it must go through both pilot plant and demonstration plant testing, which is expensive. In meetings and workshops with mining companies I found that they have little interest in such expenditures for, as long as other mining companies don't change, all remain competitive. Therefore, at this stage a government role is imperative. When the government is willing to put up part of the money for R&D it has a good negotiating position to encourage companies to either co-fund or to take over when feasibility is demonstrated.

We have held two workshops since the NAS report at the New York University Center for Science and Technology Policy on the subject of comminution efficiency improvement. In attendance were representatives of government, universities, mining companies, equipment manufacturing companies, and engineering construction firms. The conclusion was unanimous in that industry, government and universities should turn their attention to this long-neglected field and cooperate in innovation.

The negotiations between these diverse sectors have been long and delicate with respect to the appropriate role of each. These difficulties have been largely overcome and within the next few months a series of research programs will be cooperatively identified by these sectors. At this stage it would be simply disastrous for federal funding to be reduced for the field of comminution. The enormous potential for energy saving of hundreds of millions of dollars per year, reduced dependency on oil imports, as well as the careful nurturing of trust by a major industry of the federal government after years of an adversarial relationship, could all be wiped out by a decision over a comparatively small amount of money.

Sincerely yours,

Arthur C. Damask

Arthur C. Damask
Visiting Professor

vb

TENNESSEE VALLEY AUTHORITY
MUSCLE SHOALS, ALABAMA 35660
National Fertilizer Development Center
October 28, 1981

Mr. William Sonnett
Branch Chief
Agriculture and Food Process Branch
Division of Industrial Energy Conservation
1000 Independence Avenue, S.W.
Department of Energy
Washington, DC 20585

Dear Bill:

I was pleased that you and David had some interesting discussions concerning the TVA pipe-cross reactor process for the production of diammonium phosphate and monoammonium phosphate. I am sorry that I was out of the country when you called. However, Supra, Landskrona, Sweden, agreed to pay TVA for my expenses to assist them in the use of the TVA pipe-cross reactor to produce MAP. The tests were quite successful and some of the information I learned in this project will be helpful in our current project with DOE.

We have not had as much success in the production of diammonium phosphate with the pipe-cross reactor. The main reason for this poor success has been that the companies are unwilling to make the investment required for a pipe-cross reactor. This is because they have had a poor profit situation this year. Therefore, we are proposing an amendment to our contract which will allow us to build an experimental commercial size pipe-cross reactor for use by the diammonium phosphate producers. Enclosed is a draft of the proposed amendment to the contract. In our proposal we are requesting an additional $202,000 to build, install, and test a newly designed pipe-cross reactor which will be installed in a commercial plant. It is our opinion that either W. R. Grace or IMCC will cooperate with us in this project.

If we can give further assistance with this project after you have reviewed the proposal, please let us know.

Sincerely yours,

Frank T. Ingram, Senior Scientist
Process & Product Improvement Section
Division of Agricultural Development

Enclosure

An Equal Opportunity Employer

PROPOSED AMENDMENT TO THE DOE-TVA PIPE-CROSS REACTOR PROJECT
FOR THE PRODUCTION OF DIAMMONIUM PHOSPHATE AND MONOAMMONIUM PHOSPHATE
CONTRACT TV-54521A DE-A101-80CS40453

During the past year our Process and Product Improvement Section chemical engineers have been in continuing contact with primary phosphate producers in the United States to discuss with them the merits of the pipe-cross reactor process for the production of diammonium phosphate (DAP). In several instances we have made specific design recommendations for these DAP pipe-cross reactors. Although there has been some interest in the process and one primary producer in Louisiana continues to use the pipe-cross reactor for a portion of their DAP production, no primary phosphate producer has opted to use a pipe for all of their DAP production. While the profits from the production and sale of DAP were substantial about a year ago when we began this project, the production of DAP at this time results in little or no profit. Because of these poor market conditions, the commercial firms do not want to risk the use of capital in an unproven research project of this type. Because the commercial fertilizer firms are unwilling to fund this project at this time, we will need to use a new approach in our effort to test the new TVA pipe-cross reactor process for the production of DAP. We want to construct a pipe-cross reactor which utilizes our latest design criteria. This PCR would be offered to a commercial firm for testing in their plant. This new program will help solve unknowns which now exist.

We are making the following additional funding proposal to further our efforts toward completing the research work on this process. The specific dollar amounts we are requesting and how they will be spent are listed below:

1.	Design and fabrication of a DAP pipe-cross reactor for an individually selected primary phosphate producer.	$70,000
2.	Installation of this DAP pipe-cross reactor at commercial producer's DAP granulation plant.	30,000
3.	Initial test work and debugging of DAP pipe-cross reactor process in primary producer's plant	50,000
4.	Overhead	52,000
	Total	$202,000

We feel that once we have the first plant properly operating with this DAP pipe-cross reactor process, the other primary phosphate producers will observe that enough of the risk has been eliminated and will also install pipe-cross reactors. We continue to believe that the DAP pipe-cross reactor process has merit. Pilot plant tests and the initial pipe-cross reactor work at the plant in Louisiana continue to be encouraging. Lower recycle ratios, reduced fossil fuel input to the dryer, and higher operating factors for the existing DAP plants are obtainable.

The major obstacle between us and the completion of this project is economic in nature. The ongoing technical rapport between our engineers and representatives of the primary phosphate producers continues to be strong. The downturn in the economy, and specifically DAP producers' diminished profits, has made them hesitant to take any risks with new technology at this time. We believe there will be substantial energy savings if additional DOE funds can be appropriated at this time to eliminate this risk.

CHEMICAL
RESEARCH
&
LICENSING
COMPANY

December 17, 1981

Robert G. Massey
Office of Industrial Programs
U.S. Department of Energy
Forrestal Building CS-40
Washington, DC. 20585

Dear Bob,

The MTBE plant at Charter International Oil Co., Houston, Texas, which is demonstrating our novel catalyst system, has now been on stream for six months using the replacement catalyst charge provided by the DOE. I'm happy to report that the catalyst shows no signs of deactivation and everyone is very favorably impressed with the entire system's operation.

It is appropriate that the DOE be given credit and our sincerest thanks for helping this novel technology survive a very critical development period. The research funding itself has been vital to the technical evolution of the catalyst system, but without DOE support the accidential poisoning of the first charge of catalyst would have been a catastrophic loss to CR&L. Had it not been for the DOE funded replacement charge, that early mishap could have blocked fair evaluation of the catalyst system or, at best, would certainly have significantly delayed acceptance by the industry of what now appears to be a solid tool for improved energy management in chemical process engineering.

Again, our sincerest thanks to the DOE for its research funding and backup catalyst guarantee and my personal thanks to you, Bob, for your encouragement and guidance. I look forward to a continued mutually productive relationship in improving the catalyst system and expanding its uses into other application areas.

Sincerely,

Lawrence A. Smith

Lawrence A. Smith, Jr.
President

LAS/lr

713 943-0246
713 941-4646

P.O. Box 34687
Houston, Texas 77034

National-Standard

Corporate Headquarters

February 4, 1982

Dr. J. F. Collins
D.O.E. Office of Industrial
Programs
P.O. Box 23849
Washington, D.C. 20024

Re: National-Standard Company/D.O.E.
Cooperative Agreement
No. DE-FC-07-801D12163

Dear Dr. Collins:

We wish to respond to your question of our continuation of the above project if the D.O.E. were tc withdraw its support.

Initially, we believe it should be pointed out that the D.O.E. solicited contract proposals inviting the private sector to enter into a cooperative agreement with the Department to develop a technology coverting waste tires into an energy product. National-Standard Company responded to the solicitation for two reasons: we felt that we had the technical capability for the successful development of the required technology and secondly, that the amount of money already expended on waste tire disposal prohibited further capital outlay without third party participation. Additionally, the support and assistance of the D.O.E. was key in our determination to submit the proposal.

While the development has so far gone very well (ref. S.Y.P.A.) and the tire industry is responding with a high degree of interest, we cannot seriously expect any company to commit the substantial capital required for a commercial system before our successful demonstration of a system utilizing the new technology. Further, we believe the completion of this project is required to produce engineering data for the design of larger units. Without customer commitments and with the risks in developing any new technology, further research and development work by the Company without the Department of Energy funding would be unwarranted.

Niles, Michigan 49120 • Tel: 616/683-8100 • Telex: 25-6453 • TWX: 810-270-3153

It is our belief that the system will result in a new product line which will benefit both our Company and the country, and we are continuing in our efforts toward realization of a successful project. We look forward to the Department of Energy's continued support and assistance.

Very truly yours,

G. H. Frieling, Jr.
President and
Chief Executive Officer

GHF/grf

Eastern Products Corp

February 5, 1982

Dr. Jerry Collins
P.O. Box 23849
Washington, DC 20024

Dear Dr. Collins:

In response to your question as to the fate of our co-operative Waste Tire Program should the Department of Energy withdraw its' support, we have reviewed our position and capabilities and although we feel that the program will result ultimately in a successful business, we could not proceed without DOE's financial support.

The program we submitted in our proposal, we believe to be, a unique and efficient approach towards solving the problems of waste tire disposal.

Towards that end, and aided in great part by the DOE's contribution in the co-operative contract, Eastern Products has made great strides in successfully testing our methods. Indeed, as our Test Report (Co-fired Tire Derived Fuel and Oil) will show, we are successful in displacing 17% of our test host's oil needs with T.D.F. (saving of oil gal./yr., approximately ½ million gallons per year at host's facility).

We have proven the technical feasibility of co-firing T.D.F. with oil or coal (in Fluidized Bed Testing). The question of viability from an overall point of view still remains to be answered. Research is required to determine if the collection and processing of waste tires on a large enough scale to support a business is economically possible. This was the original intent of this DOE Project. Eastern Products could not generate enough capital to finance the complete project, nor because of the nature of this business, i.e., collecting scrap tires from many sources - do we believe that a large corporation would be interested in financing this type of business which in order to be profitable requires a company with exceedingly low overhead and familiarity with scrap rubber business such as Eastern Products.

More research must be completed before we could hope to attract the capital necessary for start-up. However, we believe that once we have developed the overall economical feasibility we will be able to finance other plants in major metropolitan centers to solve the problem of glut of waste tires, and to make a siginificant reduction of oil consumption.

214 Commercial Street, Malden, Massachusetts 02148 617-324-2400/TWX 710-348-2269
Plant: Dale Street, Andover, Massachusetts 01810 617-475-5133

I personally feel that it would be very sad indeed if we were forced to drop this project. We have come a long way and believe that continuing this program would in not too distant future allow us to displace a substantial amount of fuel oil with waste tires; and help to solve a serious environmental problem.

If I may be of any further assistance in this matter, please do not hesitate to call.

Very truly yours,

EASTERN PRODUCTS CORP.

Arthur H. Feinberg
President

cc: Mr. William Thielbahr

GCA CORPORATION
Technology Division
213 Burlington Road
Bedford, Massachusetts 01730
Telephone 617-275-5444
Telex 92-3339

February 4, 1982

Mr. Dennis W. Brinkman
Supervisory Research Chemist
U.S. D.O.E.
P.O. Box 1398
Bartlesville, OK 74003

Dear Dennis:

We've seen some reports in the press and heard other reports from within the Department of Energy that ongoing contract research programs may be terminated within the very near future. If the work we're doing for you now under DOE Contract No. DE-AC19-81BC10375 entitled, "The Fate of Hazardous and Non-Hazardous Wastes in Used Oil Recycling" is stopped at this time, we at GCA think the results would be tragic.

The disposal of large volumes of used oil by burning, sewer disposal, and road oiling are practices that now exist and will continue unabated in the near future. It is imperative that information concerning the fate of used oil contaminants during their disposal activities be experimentally verified. As you know, some of the contaminants which we are investigating include PCB's, benzene, pesticides, herbicides, trichloroethylene and heavy metals — all of which can be dangerous, even poisonous.

We've gone past the start-up phase of the program. Substantial time, effort and money have been spent to set up our experimental apparatus, develop our analytical procedures and schedule field tests at commercial reuse facilities. If the program is terminated now, the Dept. of Energy will have paid for the start-up efforts; yet, they will have no data.

To continue the work is to obtain experimental data which are essential to solve a difficult national problem. The extent and gravity of the problem of PCB-contaminated waste oil was highlighted recently on "20/20" - a national network news program. To continue the work will also recoup the investment made in start-up costs. The experimental data to be generated are being eagerly awaited by industry and state energy conservation and waste oil reuse agencies. We urge you to argue within D.O.E. to continue the program.

Very truly yours,

Paul F. Fennelly

Paul F. Fennelly, Ph.D.
Manager, Environmental Measurements Department

PFF/mm

cc: Bruce Cranford-U.S. D.O.E.

Peabody Gordon-Piatt, Inc
PO Box 650 | Winfield, Kansas 67156 | Telephone 316 221-4770 | Telex 417-452

The Honorable Robert Dole
U.S.Senate - Dirksen Bldg.
1st & C Streets NE
Washington, D.C. 20510

SUBJECT: D.O.E. PROJECT DE-AC03-78-ET-13148, "DIRECT COMBUSTION OF INDUSTRIAL DRY COMPOSITE WASTE IN SUSPENSION".

Peabody Gordon-Piatt

28 April, 1981

Dear Senator Dole:

Mr. Frank DeGeorge, Acting Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy is currently going through a rigorous review of a number of individual projects requesting D.O.E. funding for FY82. His difficult task is to determine the contribution each project can be expected to make in saving fuel oil, or gas, and that without Government support, industry will not proceed with the specific development in the near term. Ours is one of the projects undergoing scrutiny.

We are requesting support for the previously planned next step subsequent to a successful two year, full scale, R & D project, not a new project. This project has identified large classifications (S.I.C. Groups) of industrial organizations that generate composite waste, dispose of it, and use oil or gas to generate steam. We have completed the R & D necessary to retrofit existing boilers with suspension burners that use this waste for fuel, thereby replacing an equivalent quantity of the conventional fuel.

If, for example, only 4,200 of 42,102 plants in Standard Industrial Code (SIC) 27, Printing, Publishing, and Allied Products, supplied only 1/3 of their steam needs by using composite waste for fuel in a retrofit burner installation, more than 49 million barrels of oil per year could be saved.

Although calculations show a payback in less than 3 years, good judgment prevents these plants from engaging in a retrofit program until it has been proven to their satisfaction that the risk is acceptable. Unlike wood waste that is homogeneous, composite waste has wide and random variations in heating value, ash content, moisture content, and most importantly, combustion air requirements. We have learned how to cope with these variations while generating steam on demand, but the duration of test burns in our R & D project has not exceeded three days.

We have spent two years and nearly $710,000, of which $155,000 was our own, to get where we are. Without the next step, as proposed in the contract modification, this expenditure could well be wasted; our small company cannot support the cost.

The amount of $428,000 requested is to cover the cost of selecting a host, designing and installing the retrofit system and monitoring it for one year of full operation. The equipment costs are to be bourne by the Host plant.

We sincerely believe that the benefits of the project modification warrant the funding requested; we hope that Mr. DeGeorge will agree.

Sincerely,

M. K. Gordon, President

MKG/mr

ARMCO INC.
GENERAL OFFICES • MIDDLETOWN, OHIO 45043
RESEARCH & TECHNOLOGY

January 14, 1982

Dr. Jim Fulton
Dept. of Energy
Forrestal Blvd. C.E. - 121.3
1000 Independence Ave.
Washington, D. C. 20585

Dear Jim:

John d'Entremont recently gave me Dr. Julian Szekely's proposal for additional funding on mathematical modelling of fluid flow and heat transfer in electric arc furnaces. I think Julian and his co-workers started to make some real progress during the last year of DOE funding on the mathematical modelling of the arc and its interaction with the environment, even though it was a single phase system. I am not enough of a physicist or mathematician to really judge his work but some of their conclusions on energy transfer from the arc made good sense. I would like to see this work extended and if Julian doesn't continue it I don't know who will pick it up. I rather doubt that Julian's proposal for multiple sponsorship by steel corporations and suppliers of arc furnaces will acquire enough support to allow him to continue at a funding level of $120,000 - $150,000 per year. In fact, I doubt that I can get Armco to support this work at $15,000 per year on a shared basis. Therefore I am recommending Federal Government funding if it is still possible under the tremendous budget cutting pressure.

Very truly,

Steve Gilby

S. W. Gilby
Manager
Melting and Refining
Armco Inc.
Research and Technology

SWG/dbm

BROWNING-FERRIS INDUSTRIES

P.O. BOX 3151 • HOUSTON, TEXAS 77001 • 713/870-8100

July 7, 1981

Jerome F. Collins
Chief, Alternative Materials Utilization Branch
Office of Industrial Programs
United States Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Mr. Collins:

I am writing to enumerate reasons why Browning-Ferris Industries supports continued federal funding of research and development projects related to waste-to-energy.

As you know we have conducted tests in conjunction with the Gulf Coast Portland Cement Co., burning refuse-derived fuel to supplement natural gas in manufacturing cement. When we conceived the tests and discussed them with the cement industry, it was agreed that, if certain technical problems could be overcome, there were potential benefits.

However, the technical problems posed high risks. Because BFI is a publicly-held, profit-making company, prudent management only takes risks when the potential benefit far exceeds these risks. Funding of the waste-to-energy project by your office removed this potential loss and allowed the research to go forward. Although prior work had been done with company funding, it was on a much smaller scale and even though the results were encouraging, more extensive testing such as that funded by the Department of Energy was strongly indicated.

Browning-Ferris is principally engaged in the collection, processing and ultimate disposal of solid and liquid wastes. More often than not, the ultimate disposal is burial in secure landfills. We are always interested in ways to lessen the amount of land necessary to meet those disposal needs. Less disposal translates to better utilization of landfill space, longer landfill life and less operating costs. Disposing of part of the solid waste stream (up to 70%) by co-firing with conventional fossil fuel results in a smaller quantity to dispose of by landfilling. The financial and environmental benefits of this concept are obvious.

Federal funding of alternative fuels projects like the cement kiln tests serve another valuable purpose. Industry often requires conclusive proof that a new technique or method will lower their operating costs, increase productivity or otherwise benefit their business. This proof is in the form of success of other facilities. Succesful demonstration is aided by your funding. Timing has a part in this acceptance also. In the case of burning refuse-derived fuel, its attractiveness increases as conventional fossil fuels increase in cost and become harder to find. Federal funding allows continued research to perfect and demonstrate technical feasibility so that when it becomes economically attractive, the technical risks have been at least identified and at best solved.

Browning-Ferris believes supplementing conventional fuel with refuse derived fuel in the manufacture of Portland Cement is technically feasible. We encourage federal funding to advance the state of the art to a point where it becomes an accepted method of conserving our natural fuel supply while aiding the task of solid waste disposal.

Cordially,

Bruce Hendrickson
Vice President
BFI

United States Steel Corporation

WALDO RALL
DIRECTOR
CONTRACT RESEARCH

RESEARCH LABORATORY
125 JAMISON LANE
MONROEVILLE, PENNSYLVANIA 15146
412/372-1212 OR 351-3100

October 21, 1981

Mr. R. L. Sheneman, Chief
Advanced Extraction, Recuction, and Melting
Office of Industrial Programs
Forrestal Building, CE 121.3
1000 Independence Avenue, SW
Washington, D.C. 20585

Dear Mr. Sheneman:

Subject: FULL-SCALE PILOT FACILITY FOR DRY COOLING OF COKE - DE FC07-801 D12158

We have reached the 90-percent-of-obligation expenditure point and are preparing the appropriate modification-and-status report for the Idaho Operations Office. The program continues to show promise, but because of the innovative and high-risk concepts that are involved and the unforeseen complications that arose in the design of the pilot facility, we have had to commit more research effort and facility construction funds to the project than anticipated. These are consequences of the same high-risk and nonexclusive-benefit considerations that made us unwilling to fund the program on our own, but encouraged us to seek a cosponsor. The design, construction, heat-transfer, and maintenance problems were all unknowns, but the potential benefits of energy conservation and reduced environmental emissions appeared to justify the undertaking.

It would appear at this time that there will be at least an additional $100,000 required for the construction and installation of the pilot facility and another $150,000 required to carry out the balance of the testing, evaluation, and reporting program. We are currently detailing and substantiating the increases. We trust that your evaluation of the project and commitment to it agrees with ours and that you will continue to share in the cooperative program.

Very truly yours,

Waldo Rall

WR/tab

cc. W. C. Drake - DOE, Idaho

PO Box 630 | Winfield, Kansas 67156 | Telephone 316 [illegible]

11 February, 1982

Dr. Jerome Collins C.E. 121.2
Office of Industrial Programs
Department of Energy
Forrestal Bldg.
1000 Independence Ave., SW
Washington, D.C. 20585

Ref: DOE Contract DE-AC03-78-ET-13148

Peabody Gordon-Piatt

Dear Dr. Collins:

In the context of our recent ongoing discussions about the difficulty we have encountered in locating prospective hosts, this letter is intended to inform you of our assessment of this activity.

Peabody Gordon-Piatt, like other organizations aware of energy supply and demand trends, is certain that the cost of conventional fuels (oil and gas) is going to continue to rise. These costs are expected to follow the trend of inflation until the state of the economy improves, at which time they are expected to increase at an increasing rate.

We have chosen to fight increasing fuel costs by proving that in-plant generated dry composite waste is a commercially applicable substitute. The project will demonstrate that burning this waste will also reduce disposal costs and increase landfill life. Under a normal economic climate, such proof would convince profit oriented commercial and industrial plants to retrofit their existing oil or gas fired energy systems. Experience in parallel activities indicates that paybacks of 2 to 3 years are usual as a result of such a retrofit. Although net profit may be the incentive for the individual plant, reducing the consumption of oil or gas is the national objective.

We are not in a normal economic climate, however, and unless paybacks of 9 months to 1½ years can be clearly demonstrated, management is not making any unnecessary capital investments. This describes the barrier we have met in attempting to find host sites willing to pay for the equipment necessary to accomplish a suitable retrofit within the prescribed time period.

We believe that in about six months the economic climate will begin to improve considerably and as a result the use and cost of energy will also increase. The investment to date in time and effort toward the stated objective warrants expanding the search for prospective host sites so that we have the data to prove the benefits of such a retrofit.

Although we believe that our efforts have been commensurate with the task, we had confined our search to the three S.I.C. Groups identified in Tasks I and II of the project. As you know, we have expanded our search to additional S.I.C. Groups.

We believe that any reduction in contract effort at this time would be counter-productive for the following reasons:

- The contract team and possibly even the full scale burn test facility could be dissipated and difficult, if not impossible to reassemble.
- The discontinuity in progress would make a restart expensive and cause considerable unnecessary delay in achieving the objective of saving oil and gas by such retrofitting.
- Continuation of this effort helps the public remain aware of the requirement and that a solution exists that needs only to be demonstrated.
- This is a truly unique program. Many commercial and industrial plants generate composite (non-homogeneous) waste but burn oil or gas to meet their energy needs. Industry has shown no significant effort to develop the use of this alternate fuel, however. A retrofit of the type this project is directed toward, has wide application.

As stated, we have expanded and intensified our search for prospective host sites where the benefits from such a retrofit can be demonstrated. I trust that our effort meets with your approval. Your suggestions will be welcomed.

Sincerely,

L. G. (Lee) Desmon

L. G. Desmon
Technical Manager
D.O.E. Contract DE-AC03-78-ET-13148

LGD/mr
copy: Kern Gordon, President

construction technology laboratories

a Division of the PORTLAND CEMENT ASSOCIATION

5420 Old Orchard Road, Skokie, Illinois 60077 • Phone 312/966-6200

February 8, 1982

Dr. Michael B. McNeil
Program Manager
U.S. Department of Energy
66090 Forrestal Building, CE-122
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Mike:

Your question relative to the action that would be taken by the Construction Technology Laboratories in the event funding of the "Particle Size" project was suspended is very easy to answer. We would stop work immediately and prepare termination charges at the earliest possible time.

I realize that you are cognizant of the fact that CTL is a division of a not-for-profit organization and has very limited funds with which to operate. The CTL is a research, development and technical service agency and our staff and equipment are available on a contract basis to government and industry. Also, the current project "Energy Conservation Potential of Portland Cement Particle Size Distribution Control, Phase II" is being performed under a cooperative agreement and the CTL is providing 15% of the cost.

The CTL operates within facilities that were originally constructed for research and development projects funded by members of the Portland Cement Association. But in 1969, as a result of adverse economic conditions, the support of the industry was drastically reduced and the services of the laboratories were offered to governmental agencies, all of private industry and the public in general on a contract basis. This has continued to the present time. Currently less than 25% of our work is supported by the Portland Cement Association and over 75% is performed on a contract basis. There is no indication that the economy of the cement industry has or is about to improve, and increased support for the laboratories is not anticipated in the predictable future.

The project in question will provide data for a breakthrough in the specification of portland cement, the cementing material used in concrete which is required in 90% of all construction projects in the United States. The energy savings and economic benefits that will result from the project will accrue to the depressed construction industry.

construction technology laboratories

Any delay, reduction or suspension of funds for the particle size control project will have a serious effect on the research program and staff of a research organization of our size. Although you are familiar with the CTL organization, if I can be of service please feel free to call on me.

Yours very truly,

George K. McCord

George K. McCord, Director
Project Development

GKMcC/lg
HA-1155-4000

Copy to -
W. E. Kunze

SIDBEC
507, Place d'Armes, Montréal, Québec H2Y 2W8

January 5, 1982

Dr. James Fulton
U.S. Department of Energy
Division of Industrial Energy
Conservation
CE 121.3
Forestall Building
Washington, DC 20585

RE: Mathematical Modelling of
Electric Arc Furnaces

Dear Jim,

Following up on the meeting at MIT on December 3, 1981, this is to indicate to you our interest in this development program. Certainly, this project sponsored by the U.S. Department of Energy has permitted an improved understanding of the behaviour of electrical plasmas. From a practical view point, it is important that additional measurements are made in an industrial environment to permit further validation or modification of the models developed. I certainly hope that this further step in the research program can find adequate sponsorship.

I have already indicated to Dr. Julian Szekely that I would be prepared to participate in any discussions on how this program might be continued.

It was good to have the chance of seeing you again at MIT and I would like to take this opportunity to convey my best wishes for the New Year.

With kind personal regards,

TED/mh

Terence E. Dancy
Vice-President
Technology

c.c.: Dr. J. Szekely

8. Q. Please provide for the record copies of the original FY 1983 request from the Assistant Secretary for CE to the Under Secretary in August or early September 1981 (i.e. before the budget revisions required by OMB in September 1981). Please provide all back-up and justification material.

A. See attached information.

FY 1983 Internal Review Budget
Assistant Secretary for Conservation
and Renewable Energy

July 13, 1981

Summary Tables

FY 1983 Internal Review
Assistant Secretary for Conservation and Renewable Energy Programs
AS/CE REVISIONS

Program	CE Submission Target	AS/CE Revisions Change	AS/CE Revisions Revised Total
Solar Energy			
Active	10.0	0	10.0
Passive	11.0	0	11.0
Photovoltaics	65.0	-22.0	43.0
Thermal	46.0	-6.5	39.5
Biomass	22.5	-5.5	17.0
Wind	24.0	-1.9	22.1
Ocean	0	+7.2	7.2
International	5.5	+4.5	10.0
Information	4.0	+2.0	6.0
Alcohol	11.0	0	11.0
SERI	0	+24.0	24.0
Program Direction	4.5	0	4.5
Total	203.5	+1.8	205.3
Other Renewable			
Geothermal	54.0	-12.0	42.0
Geothermal Fund	0.2	0	0.2
Hydropower	0	+0.6	0.6
Total	54.2	-11.4	42.8
Energy Storage/Electric Energy			
Storage	35.9	-1.8	34.1
Electric Energy Systems	9.0	-3.1	5.9
Total	44.9	-4.9	40.0

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FY 1983 Internal Review
Assistant Secretary for Conservation and Renewable Energy Programs
AS/CE REVISIONS

Program	CE Submission Target	AS/CE Revisions Change	AS/CE Revisions Revised Total
Energy Conservation			
Buildings and Community Systems	25.0	-3.2	21.8
Industry	0	+3.3	3.3
Transportation	35.9	-10.2	25.7
State and Local	107.4	-104.4	3.0
Multi-Sector	17.1	0	17.1
Total	185.4	-114.5	70.9
Power Marketing			
Southeastern	11.8	0	11.8
Southwestern	38.1	0	38.1
Alaska	3.4	0	3.4
Western	226.9	0	226.9
Total	280.2	0	280.2
Policy and Management	10.8	-2.3	8.5
Grand Total	779.0	-131.3	647.7

FY 1983 Internal Review Budget
Assistant Secretary for Conservation
and Renewable Energy

July 13, 1981

Back up/Justification

FY 1983 Internal Review
Assistant Secretary for Conservation and Renewable Energy Programs
Overview
AS/CE REVISIONS

Current CE Submission		AS/CE Revisions			
Program	Target	Revised	Change	Activity	
Buildings and Community Systems	$ 25.0	$ 21.8	- 3.2	- 3.4	Buildings Systems - Pilot Projects
				- .7	Field Testing, Commercial
				- 1.0	Field Testing, Residential
				- 1.1	Case Studies, Commercial
				- .6	Case Studies, Residential
				- 1.8	Building Systems - Energy Conversion
				-1.8	Level of Effort Reduction
				+ 2.0	Federal Energy Management Program
				+ 2.0	Facility Surveys
Transportation	$ 35.9	$ 25.7	- 10.2	- 4.0	Vehicle Propulsion Technology Development
				- 3.5	Auto gas turbine & Stirling
				- 3.0	Ceramics production
				+ 2.1	Diesel ceramics
				- .1	Vehicle aerodynamics
				+ .5	Project evaluations
				- 1.1	Electric and Hybrid Vehicle R&D
				+ 2.6	Electric vehicle batteries
				- 3.7	Advanced vehicle R&D
				- 5.1	Alternative Fuels Utilization
State and Local Assistance Programs	$ 107.4	$ 3.0	-104.4	- 102.1	Schools and Hospitals Grant Program
				- 2.3	Program Direction

FY 1983 Internal Review
Assistant Secretary for Conservation and Renewable Energy Programs
Overview
AS/CE REVISIONS

Current CE Submission Program	Target	AS/CE Revisions Revised	Change	Activity	
Electric Energy Systems	$ 9.0	$ 5.9	- 3.1	- 2.9	System Architecture and Integration
				- .3	Homeostatis control concepts
				- 1.4	Post-outage system restoration
				- .1	Planning under uncertainty
				- .6	Control of large-scale systems
				- .5	Multi-variable control theory
				- .1	Power Delivery
				- .1	Feasibility studies, motors
				- .1	Generation and Storage Analysis
				- .1	CAES installation
Energy Storage	$ 35.9	$ 34.1	- 1.8	- 1.8	Physical and Chemical Energy Storage
				- 1.3	Air storage experiments
				- .5	Exploratory storage system
Multi-Sector	$ 17.1	$ 17.1	---	---	Energy Conversion and Utilization
				- 2.2	Stirling/closed-cycle systems
				- .3	Sensors and control systems
				- .5	Deploymerization reactions
				+ 3.0	Ceramics production (from Transportation Program)
Industry Programs	$ ---	$ 3.3	+ 3.3	+ 1.3	Industrial Heat Pumps
				+ 1.4	Energy Integration for Farms
				+ .2	Industrial Reporting
				+ .4	Program Direction

FY 1983 Internal Review
Assistant Secretary for Conservation and Renewable Energy Programs
Overview
AS/CE REVISIONS

Current CE Submission		AS/CE Revisions			
Program	Target	Revised	Change	Activity	
Photovoltaics	$ 65.0	$ 43.0	- 22.0	- 5.0	Device Research - 5.0 Advanced Power Conditioning
				- 6.0	Systems Research
				- 5.0	Component Technology
				- 6.0	Systems Experiments - 4.0 Central Power Station - 2.0 Residential Experiments
Solar Thermal	$ 46.0	$ 39.5	- 6.5	- 6.5	Technology Development - 6.5 Central Receiver Technology - 5.0 Receiver sub-systems - 1.5' Systems Analysis
Biomass Energy Systems	$ 22.5	$ 17.0	- 5.5	- .4	Herbaceous Production - .4 Equipment Development
				- 4.8	Thermochemical Conversion - 2.1 Synthetic Gas - 2.2 Liquid Fuels - .5 Mechanical Power
				- .3	Biochemical Conversion - .3 Petrochemical Substitutes
Wind Energy Systems	$ 24.0	$ 22.1	- 1.9	- .4	Systems & Operations Analysis - .4 Application Analysis
				- 1.5	Wind Characteristics - 1.5 Wind Prospecting

FY 1983 Internal Review
Assistant Secretary for Conservation and Renewable Energy Programs
Overview
AS/CE REVISIONS

Current CE Submission		AS/CE Revisions			
Program	Target	Revised	Change	Activity	
Solar International	$ 5.5	$ 10.0	+ 4.5	SOLERAS Agreement	
Solar Information	$ 4.0	$ 6.0	+ 2.0	Inquiry and Referral Dissemination	
SERI Permanent Facility	$ ---	$ 24.0	+ 24.0	+ 2.0	Engineering Design and Inspection
				+ 22.0	Construction
Geothermal	$ 54.0	$ 42.0	- 12.0	+ 4.0	Hydrothermal Industrialization
				+ 4.0	Raft River
				- 12.0	Geopressured Resources
				- 10.0	Wells of opportunity
				- 2.5	Long Term Aquifer Drilling
				+ .5	Supporting Research
				- 4.0	Geothermal Technology Development
				- 4.0	Hot Dry Rock
				- 3.0	Site 2 Project
				- .8	Resource Evaluation
				- .2	Commercial Feasibility
Hydropower	$ ---	$ .6	+ .6	+ .4	Hydropower Development - monitoring
				+ .2	Program Direction
Ocean Energy Systems	$ ---	$ 7.2	+ 7.2	+ 7.0	Engineering Test and Evaluation
				+ .2	Program Direction
Policy and Management	$ 10.8	$ 8.5	- 2.3	- .8	Special Projects
				- 1.5	Policy Planning and Evaluation

9. Q. Please explain why technology development is no longer considered a proper Federal role by this Administration. Specifically how is it a "waste of the Nation's resources" to "accelerate the development" of technologies "that are not yet economically competitive" if these technologies ultimately save consumers money, reduce our imports of foreign oil and increase the productivity, competitiveness, and profitability of U.S. industry?

A. It is the intent of the Administration to concentrate limited Federal funding on fundamental research designed to build a technology base that can provide the foundation for future development of commercial products by the private sector. Market forces will tend to produce those technologies which are most likely to be economically competitive. The realistic energy pricing policies of this Administration, in conjunction with the incentives provided by the Economic Recovery Tax Act of 1981, should provide the proper atmosphere for such free operation of market forces. Such operation is considered to be the most efficient means by which to achieve the development of those technologies which will be most beneficial to the Nation.

10. Q. Please estimate the loss in energy savings to the U.S. economy and dollars to the U.S. Treasury in FY 1990 that will result from the decision to terminate the Industrial Energy Conservation program in FY 1983.

A. Since we feel that industry will continue those programs offering economic potential, although at a somewhat slower pace for those technologies with fewer cost effectiveness benefits, we are unable to assess the extent of the possible loss in energy savings or loss in dollars to the U.S. Treasury in 1990.

11. Q. Please provide direct evidence to support your contention that the private sector will pick up the development and demonstration activities in industrial energy conservation, technology and consumer products, passive solar, solar thermal power and photovoltaics.

A. Although the private sector is expected to pick up some such activities, it should be pointed out that the reduction in budget levels was not contingent upon such action by the private sector. Some of the activities which will not be Federally supported lack sufficient promise to warrant continued investigation. Therefore, the budget decisions have been based upon considerations that may override the simple question of private sector support for such activities.

The following are examples of private sector pick up of industrial energy conservation and technology and consumer products activities:

- Companies such as Armco Steel and Pre Finished Metals have picked up and installed "Fumes as Fuel" coil coating technologies that were developed by DOE.
- Foam finishing technologies have now been picked up and used by Dan River Mills and Galaxy Carpets after completion of DOE-funded R&D.
- U.S. Steel and Bethlehem Steel have picked up and installed Advanced Ceramic Recuperators developed by DOE.
- Garrett has expanded its product line to include larger-sized Advanced Metal Recuperators as a result of completed DOE-funded research. The company now has orders for each of the larger-sized units.
- A heat-pump water heater developed under a cost-shared program with DOE is now being marketed by 5 non-DOE-funded manufacturers. More firms are expected to enter the market soon.
- A flourescent Circline Lamp with Electronic Ballast, also cost shared with DOE is now being marketed by Sears and Roebuck. The lamp replaces the standard 188 watt bulb for residential-type applications.

For several renewable energy technologies, including passive solar energy systems for buildings, the Federal role in R&D has been essentially completed and industrial capabilities and consumer demand have built to the point where the private sector can assume primary responsibility for continued development or commercialization. For others, including both photovoltaic and solar thermal energy systems, continuation of Federal participation in research is required to provide the technical basis for industry to develop these concepts to a point where potential suppliers and users may begin making their own capital investment.

More than being a unique set of hardware, passive solar energy for buildings requires that architects, designers, engineers, and builders utilize existing technology and equipment more effectively. Several factors point to the assimilation of passive solar into the mainstream of the building trade industries, including the following:

- A Passive Solar Industries Council (PSIC), comprised of 37 major trade organizations, has been established to further the development and utilization of passive solar building technologies. Among other activities, the PSIC sponsors a periodic journal of passive solar research and development.
- Through its market promotion division, the International Union of Bricklayers and Allied Craftsmen is sponsoring training programs for contractors and bricklayers on the advantages of passive solar design and its marketing potential.
- International Masonry Institute (IMI) is marketing passive solar designs and a passive solar kit for distribution to local/regional masonry groups.

- A comprehensive promotion program for passive solar in the construction industry is being conducted and completely funded by the American Wood Council.
- The American Institute of Architects, in its largest financial commitment ever made to a single issue, launched a three year professional development program in 1981 aimed at increasing the skills of members in energy-conserving design, including the proper use of passive solar concepts.

The Department plans to continue solar thermal research, including several projects aimed at further developing the basic technology, through FY 1983. Several factors point to a growing industrial interest in, and commitment to, solar thermal technologies, including internal investment in research and development. These factors include:

- Industry interest in the Solar Thermal Energy Systems program is significant, with over 50 firms conducting R&D. The addition of suppliers swells this total to over 400 firms.
- This interest is geographically diverse with R&D firms located in 21 States and supplier firms located in 39 States.
- All technology options (central receivers, dishes, troughs and bowls) are being developed, with the largest number of initiatives on central receivers and parabolic dishes.
- Two companies (Solar Kinetics and Acurex) have set up test and demonstration parks with their equipment on display.

The Department intends to pursue photovolatic research in FY 1983. Similar to the case of solar thermal; photovoltaic industrial interests are making increasing commitments to photovoltaic research, development, production, and sales. Key observations include:

- 1981 sales of photovoltaic arrays and systems are estimated at $75 million (a 50% increase over 1980).

- Exports rose from $14 million in 1979, to $25 million in 1980 and are estimated at $40 million in 1981.
- Industrial investment in product development and automation and expansion of production facilities exceeded $100 million.
- Atlantic Richfield has invested in one of the largest known single-crystal silicon cell production facilities.
- Low-cost, high-purity silicon will be produced within three years by a new process being developed jointly by Phillips Petroleum and Aero Chemical Research Lab.
- SOLAREX plans a 6 megawatt photovoltaic plant for startup in September 1982. Some 3,000 powerline panels will provide all electricity needs without utility backup.

12. Q. Please provide for the record copies of the original documents prepared for your office by the CE programs for the DOE Sunset Review.

A. We are providing for the record draft copies of the DOE Sunset Review, dated October 20, 1981, which were prepared by CE programs. These copies have gone through many iterations, since they were originally prepared prior to the final FY 1982 budget and the FY 1983 budget request. As a result, the copies provided should be considered preliminary internal staff working drafts which do not necessarily reflect current DOE policy or budgets.

13. Q. Oak Ridge National Laboratory estimated the benefits to the Nation of oil imports saved by the DOE conservation programs, as they were structured in FY 81, to be $20 billion. (Eric Hirst, et al., "Improving Energy Efficiency: The Case for Government Action," March 1981. Please provide any evidence that contradicts that estimate.

A. DOE believes that ORNL's assumptions and methodology overstate the likely impacts of Federal conservation programs.

In our analyses, we have found that market forces, including energy's high price, are largely responsible for improved energy efficiency. The contribution of DOE's programs are believed to be relatively small, probably accounting for 5% or less of the total in 1981.

More important than this question of their effectiveness, however, is the question of whether they are needed, particularly in this time of budget austerity. While some programs may have been cost effective, cost effectiveness alone is not a sufficient condition for Federal involvement

In the case of conservation, the Administration believes that the market, for the most part, is working effectively on its own. Hence, the conservation programs of the past, implemented in times of energy price controls, are no longer needed.

14. Q. Please provide, on a program-by-program basis, the exact amount of funding being re-programmed to cover termination costs in FY 1982. Will a reprogramming or deferral notice be sent to Congress to cover termination costs?

A. We are now reviewing the FY 1982 budget and program plans in detail to identify where terminations will occur. As plans are finalized, we will be able to identify requirements for reprogramming of funds appropriated by Congress. All appropriate Congressional notifications will be made. We hope to complete our reviews, and forward appropriate reprogramming notifications, within the next few weeks, although we will continue to look for possible terminations throughout the year.

15. Q. No mention is made in the FY 1983 budget of funds to operate and collect data from a number of solar demonstrations and test facilities. These include:

a. Shenandoah.
b. Other solar thermal power demos (e.g. Coolidge).
c. Solar Thermal Test Facilities at Sandia, Edwards AFB and Georgia Tech.
d. Mod-2 Wind Turbines.
e. Rocky Flats Small Wind Test Facility.
f. Photovoltaics PRDA's.
g. Georgetown, MCCC, Senatobia Photovoltaics Demos.
h. Northeast, Southwest Residential PV Experiments.
i. National Solar Data Network.
j. Passive Demos and Test Modules.

Please describe for each item how the Department intends to dispose of the facility; what the costs of that disposal will be; what information will be lost as a result of failure to collect data from the facility?

A. The requested information is as follows:

a. Negotiations are underway with Georgia Power Company to transfer ownership of the Shenandoah solar total energy system to the utility.

b. Discussions are underway with Arizona State University to transfer ownership of the Coolidge solar irrigation experiment to the State of Arizona. Negotiations are underway with the Southern California Edison Company to transfer ownership of the DOE-funded portion of the Barstow pilot plant to the utility. Other solar thermal field installations, including industrial process heat experiments, typically have the site participant assume

ownership of the solar equipment at the point it is operational. Funds have been allocated in FY 1982 and prior years to provide necessary data collection for one or more years of experimental operation.

c. For solar thermal test facilities, no specific arrangements have been completed for disposition since these facilities will be operated with FY 1982 funds to complete tests of experimental equipment funded in FY 1982. Since the facilities are convenient to centers of private research or are on Federal land, they can conveniently be mothballed or made available for privately-funded research. For all of the above items, it is expected that costs of disposition will be within funds available in FY 1982 or requested in FY 1983. No information will be lost as a result of their disposition, because the facilities have either served their intended purpose or will be operated through an appopriate period of testing by private parties.

d. Discussions are underway concerning potential transfer of the Mod-2 wind turbines to the Bonneville Power Administration at no additional cost. Sufficient information is being collected to complete analysis of operational data from these machines in FY 1983.

e. The Rocky Flats small wind test facility is on Federally owned property. While the activities at this facility are being phased out and no additional funding is being requested in FY 1983, specific plans for disposal of equipment are currently being developed.

f. The photovoltaic PRDA experiments have the equipment title vested with the user with 2 years of operation and evaluation included as a part of the contractual arrangements made. These projects are fully funded and no loss of desired information is expected.

g. The Georgetown project is expected to be operational in 1985. Equipment title will be vested with the user and there are no plans for test and evaluation. The Mississippi County Community College project has equipment title vested with the user 2 years of operation and evaluation are planned. The project is fully funded. The Senatobia project is in abeyance pending resolution of issues identified in an audit.

h. The Northeast and Southwest residential experiment station are funded for operation through FY 1983. Attempts to have these stations operated by private organizations with continued data collection are currently underway.

i. The National Solar Data Network facility will phase-out by January of 1983. The costs associated with this phase-out are currently estimated at $500,000 of current year funds.

j. Passive Demos and Test Modules are comprised of two activities. Class A uses instrumented control environments, known as test modules, to provide experimental data for improving building energy analysis methods and cost/performance assessments.

Class B obtains actual system performance data from passive residential and non-residential buildings; to be used in developing, refining, and validating simplified design tools. Class A test modules are located at the National Bureau of Standards and at national laboratories where they are likely to remain. The Class B activity is primarily conducted by SERI and involves privately-owned buildings. Therefore, termination of these activities should not result in a significant cost for disposal of the facilities. The FY 1982 program will provide valuable information relative to simple structures. It will be the responsiblity of the private sector to continue performance monitoring activities if the building industry determines that such data is needed.

16. Q. Which national laboratory solar activity centers will be terminated as a result of the FY 1983 budget proposal?

A. No national laboratories will be terminated as a result of the FY 1983 budget proposal.

17. Q. Please provide a break down on a program by program basis (i.e. industrial energy conservation, photovoltaics, etc.) of the total dollar value of procurements that have been signed by the Assistant Secretary for Conservation and Renewable Energy in FY 1982 as of March 1, 1982.

A. Please see attached chart.

STATUS OF FY 1982 BUDGET EXECUTION
CONSERVATION AND RENEWABLE ENERGY
(DOLLARS IN THOUSANDS)

	FY 1982 Total Obligation Authority	PR's/Grants Authorized by CE thru 3/8/82	
Multi-Sector	17,820	7,834	44%
State & Local	258,320	100,759	39%
Electric Energy Systems	20,793	8,130	39%
Storage	39,200	10,632	27%
BCS	54,039	21,299	39%
Energy Imp. Asst.	940	-0-	0%
Industry	35,407	8,369	24%
Transportation	62,936	38,959	62%
	489,455	195,982	40%
Solar	269,974	159,258	59%
Geothermal	46,039	31,137	68%
Hydropower	3,586	1,009	28%
Geo. Rec. Dev. Fund	3,565	200	6%
	323,164	191,604	59%
	812,619	387,586	48%

18. Q. What is the status of the following activities that were included in the FY 1982 DOE Appropriations Bills but not requested by the Administration:

a. PON for solar repowering preliminary design.

b. Small community solar experiment.

c. Southeast residential photovoltaics experiment.

A. a. The FY 1982 Energy and Water Appropriations Bill provided $6 million for multiple solar thermal central receiver repowering designs. The Department has authorized the immeditate release of the Program Opportunity Notice (PON) to solicit repowering preliminary designs. The completion of the Advanced Conceptual Design Studies now underway, and the successful operation of the 10 MWe Pilot Plant at Barstow, California, will provide a basis for the private sector to proceed into design and construction of a repowering project without further Federal assistance.

b. In the case of the small community program, DOE staff are developing plans for expenditure of appropriated funds.

c. Procurement plans for a photovoltaic Southeast residential experiment station are currently being developed and should be prepared by the end of April 1982. An award for the establishment and operation of the station is expected to be made by the end of FY 1982.

19. Q. With respect to hydrothermal industrialization, the FY 1983 budget documents state that "certain hydrothermal applications are currently cheaper than other energy alternatives." Would you provide examples to support this contention?

A. The Geysers geothermal power plants of PG&E in California produce power at lower costs than any other PG&E source except hydropower. A recent analysis of seven U.S. direct heat applications showed five significantly less expensive than any alternatives. Particularly where geothermal directly displaced imported oil, such as in Italy, Japan, and Ireland, hydrothermal applications are expanding due to their cost advantages.

20. Q. Environmental control technology will receive no funds under the FY 1983 request. Why was this effort zeroed out?

A. The effort is not being zeroed out, but will be carried under other program line items. Long-term research will be conducted in FY 1983 to address unresolved problems critical to the environmentally-safe disposal of spent brines, to subsurface movements of injected fluids and to special emission control problems of liquid reservoirs.

21. Q. Regarding the Hot Dry Rock program, the agreement between the U.S., Japan and West Germany provided that the foreign contributions would be leveraged based on a U.S. contribution of $5 million.

In halving our contribution, we will loose a proportionate share of our co-sponsors' support, so that the total R&D effort will suffer to a greater degree than the U.S. budget may indicate.

Has DOE discussed the effect of such a reduction with the other partners? What was their response? Will this reduced funding level bring the technology to a point that industry can evaluate its potential?

A. DOE representatives have discussed the FY 1983 budget with representatives of both West Germany and Japan. Neither country has as yet responded officially to the proposed budget. The amount requested will be applied to additional fracturing and testing of the large thermal loop at Fenton Hill. This work will provide important information needed for industry to evaluate the potential of hot dry rock technology.

22. Q. The FY 1983 budget terminates Federal involvement in the Heber Plant and will "leave completion to the private sector."

During the FY 1982 Authorization hearings, San Diego Gas and Electric testified that "withdrawal of Federal funding would cause termination of the project." The GAO reached the same conclusion in a June 1981, study.

The 50/50 Cooperative Agreement is evidence of industry's good faith to carry the project to fruition with Federal support. In addition, the Federal share may be returned through revenue sharing, and the Government is not liable for cost overruns. Finally, the technology base will not be proprietary as the agreement provides for data dissemination to industry.

The commerical considerations, coupled with the magnitude of the exploitable resource, targeted by the Interagency Geothermal Coordinating Council at 25,000 MW by the year 2000, seems to amply qualify this project for continued support.

In light of the previous testimony by SDG&E, and the GAO study, do you perceive that the private sector will complete this project?

A. We expect the private sector to be able to continue the project without Federal funding in FY 1983. In order to reach this goal, we will be working with our Heber partners on a plan to complete our funding contributions during the current fiscal year and also reduce government involvement in project management.

23. Q. If the Heber project is not completed, what will be the effect on hydrothermal resource development, specifically with respect to the Interagency Geothermal Coordinating Council's development goal? Has DOE foregone this goal?

A. We expect it to be completed.

24. Q. To what extent was the cost and revenue sharing agreement considered in arriving at the conclusion to terminate Federal involvement in the Heber project?

A. Cost and revenue sharing are critical issues in our plans for completion of Federal Funding involvement in FY 1982.

25. Q. At the time the cooperative agreement was written, this project was apparently deemed worthy and viable. From the standpoint of technology base development potential, what has changed to bring about termination?

A. We do not expect project termination, but rather the need for no further Federal funding after FY 1982.

ADDITIONAL ANSWERS TO QUESTIONS SUBMITTED BY THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
TO ASSISTANT SECRETARY TRIBBLE OF THE DEPARTMENT OF ENERGY

1. Q. The Committee has been seriously concerned lately about the manpower resources available in DOE to carry out its FY 1982 program responsibilities. These concerns are based on numerous reports indicating that many key personnel are now leaving the Department for other jobs. Do you believe that there are adequate manpower resources currently available in the Department to effectively carry out your program requirements for this fiscal year? What steps is DOE taking to make sure that this problem is kept under control? Does the Department plan to carry out any additional RIF's in the near future.

A. Based upon a review of program commitments and responsibilities, we find that CE currently has the manpower resources to maintain all of its scheduled program operations. In addition, as vacancies occur in critical program areas, we have directed that personnel currently assigned to our lower-priority activities be transferred into our critical program areas. In this manner, we hope to "cross train" the existing work-force in new skills and responsibilities, while retaining old institutional knowledge.

The Department is currently reviewing options to meet FY 1982 ceiling levels.

2. Q. In his recent budget request, the President indicated that he may recommend the repeal of several energy tax credits when he submits his tax package to Congress in the near future. The credits which would be subject to repeal would include the Business Energy Tax Credits, the Alcohol Fuels Tax Incentives, and various other energy tax credits which have been passed in the Energy Tax Act of 1978 and the Windfall Profits Tax Act.

A. The Administration's position is to recommend repeal of these tax incentives. At the time the energy tax incentives were enacted, price controls and supply allocations were in effect on both crude oil and natural gas prices paid by consumers were substantially below replacement costs, as reflected by the price of imported oil. Oil imports were growing at the same time that domestic consumption was being subsidized and domestic production discouraged.

However, since enactment of the credits, crude oil prices have been decontrolled. In addition, natural gas prices are rising under the Natural Gas Policy Act. As a result, the credits, whatever their original justification, are no longer needed because most firms confront prices closer to replacement cost of energy and, therefore, have more incentive to invest in energy conservation and renewable energy and to purchase alternative fuels without targeted tax incentives.

In general, tax incentives for specific investments are inconsistent with the Administration's philosophy of relying on markets to allocate resources efficiently rather than on Federal programs. In addition, targeted tax incentives distort the allocation of resources, encouraging firms to

undertake investments that are uneconomic at current market prices, and to purchase higher cost fuels where a lower cost substitute is available. As a result, these incentives divert resources from more productive uses elsewhere in the economy and lower the net productivity of the capital stock.

Moreover, by reducing the cost of only some conservation measures, the incentives discourage other, potentially more efficient approaches. New inventions and refinements in old technology not covered by the subsidy are at a disadvantage in the market when the Federal government interferes to subsidize substitutes.

3. Q. The Science and Technology Committee spent a great deal of time during its FY 1982 budget hearings in trying to developo a balanced energy program. The Committee's final product reflected a carefully thought-out compromise that would allow our Nation to proceed with the development of promising new energy technologies. However, it has come to the Committee's attention that the Department may be lagging behind in carrying out the will of Congress for FY 1982. These include various solar and geothermal projects such as the Heber geothermal demonstration project, the SE solar photovoltaics residential experiment, the repowering initiative and several others. Do you believe, Mr. Assistant Secretary, that the Department is carrying out its responsibilities, as set forth in the relevant Authorization and Appropriations Act for FY 1982, to the best of its abilities? Are you aware of any instances where DOE will not carry out specific program requirements requested by Congress in FY 1982? If so, do you plan to submit many rescission or deferral requests in these areas in the near future? Would you please tell the Subcommittee the Department's phase-out plans for programs scheduled to be terminated in FY 1982, 1983 and 1984?

A. We are continuing to fund the Heber plant and to work with our industrial partners on a plan to complete Federal funding during the current fiscal year. This will ensure that lessons learned from this project will be directly applicable to future private plant development. An award by the photovoltaics program for the Southeast Residential Experimental Station is expected to be made in later summer.

In the repowering area, the FY 1982 Energy and Water Appropriations Bill provided $6 million for multiple solar thermal central receiver repowering designs. The Department has authorized the immediate release of the Program Opportunity Notice (PON) to solicit repowering preliminary designs. The completion of the Advanced Conceptual Design Studies now underway, and the successful operation of the 10 MWe Pilot Plant at Barstow, California, will provide a basis for the private sector to proceed into design and

construction of a repowering project without further Federal assistance.

The Department has already requested rescission of $14.3 million from the energy conservation appropriation for the Energy Impact Assistance program, and a deferral of $4.0 million in the Ocean Thermal Energy Conversion program to defer funding for design work until 1983. We are now reviewing the FY 1982 budget and program plans in detail to identify reprogramming actions which require Congressional notification. Reviews should be completed within the next few weeks, although we will continue to look for possible terminations throughout the year.

4. Q. As you are well aware, Mr. Assistant Secretary, the Science Committee has spent a great deal of time looking at the impact of oil decontrol on the ability of the private sector to carry out promising energy R&D programs. In recent months, Mr. Secretary, the Committee has heard testimony indicating that there are many technical risks and economic uncertainties associated with the development of these technologies. For example, the GAO has indicated that the elimination of Federal funds for the Heber geothermal demonstration project would severely affect the development of our Nation's geothermal resources. Do you agree? On the other hand, do you believe that new tax incentives, such as accelerated cost depreciation, could provide sufficient incentives to stimulate the development of promising new technologies in the private sector?

A. We expect the private sector to be able to continue the Heber geothermal binary power plant project without Federal funding in FY 1983. We will be working with our industrial partners to complete the necessary Federal support during the current fiscal year. The accelerated depreciation allowed under the Economic Recovery Tax Act of 1981 should be sufficient incentive.

5. Q. In response to a request from Deputy Secretary Davis, the Energy Research Advisory Board (ERAB) recently released its report on Federal Energy Research and Development Priorities. This report included several noteworthy conclusions in the conservation and renewable energy area. For example, the ERAB panel found that conservation R&D should be a high priority program activity. To what extent have the ERAB panel's recommendations been factored into your FY 1983 budget recommendations?

A. The recommendations of the Energy Research Advisory Board (ERAB) were but one source of input into the DOE decision making process. The ERAB recommendations were somewhat vague and of a general nature and provided no recommendations of specific research needed. The advice given to us by this Board was, therefore, considered in the larger context of Presidential economic and energy policy.

We agree with ERAB that, in the areas of conservation and renewable energy, there exists a large potential for increasing the efficiency of the Nation's overall energy use. Our FY 1983 budget reflects the Administration's conviction that, with a realistic energy-pricing policy, the marketplace can realize this potential more efficiently and effectively than the government can. We also believe that higher and more realistic energy prices will provide adequate incentives to industry to undertake needed R&D, where considered economically benefical.

6. Q. Over the years, numerous reports have criticized the management of DOE's conservation and renewable energy programs, Both GAO and the Office of Technology Assessment have criticized DOE for failing to adequately plan and evaluate its conservation and renewable energy activities. GAO has also indicated that stronger controls over solar project selections and administration would be highly desirable. Do you agree with these criticisms? If so, what steps has DOE taken to solve these problems?

A. CE generally agrees that stronger controls over project selections is warranted and that increased planning and evaluation of conservation and renewable energy activities is desirable. Previously, CE management met with Mr. J. Dexter Peach, Director of GAO's Energy and Minerals Division and discussed major management issues confronting the Office of CE. In order to address the GAO concerns, CE initiated a new management control system known as the Conservation and Renewable Energy objectives. The objectives include all major program efforts and relate resources to planned objectives. Each program has identified major milestones and primary activities. Monthly status reports detail progress made against those milestones and problems are flagged for the attention of senior management. Periodic program reviews are conducted to assure that adequate resources are being allocated to areas requiring increased attention.

Additionally, a major management improvement has focused on the procurement process. All consulting and support service procurements, plus all other procurements in excess of $1,000,000, receive the personal review of the Assistant Secretary or his staff to ensure that they are fully

justified, cost effective, and consistent with applicable policies and management principles. Extremely tight controls have been placed on conferences and travel to minimize unnecessary expenditures.

A "Management Plan for the Solar Energy Research Institute and Regional Solar Energy Centers" was adopted in February 1981. This comprehensive document is designed to improve the Department's management responsibilities of those contractors.

7. Q. As my colleagues are aware, Mr. Assistant Secretary, the Science Committee originally established the Solar Energy Research Institute in 1974 as part of the Solar Energy Research, Development, and Demonstration Act of 1974. Over the years, the Committee has been very interested in maintaining an institute of national excellence which focuses primarily on solar energy research. What is the future of SERI in light of the dramatic budget cuts which the Administration has requested for solar energy for FY 1983?

A. SERI will continue to be the primary Federal solar energy research, development, and testing facility. Even though there is no separate line item for SERI in the DOE budget, we plan to have SERI conduct activities in photovoltaics, solar thermal, biomass and alcohol fuels. Our current FY 1983 planning level for these efforts at SERI will remain essentially level.

8. Q. The Committee has spent a great deal of time recently in looking at the future of the National Laboratories and their role in our Nation's energy program. With significant budget cuts in many areas, the Committee is concerned about the impact of these cuts on these National Labs. What do you see as the role of the National Labs in your energy programs in the future? To what extent will these National Labs. actively participate in program activities under your jurisdiction during FY 1983?

A. Conservation and Renewable Energy (CE) program funding is earmarked primarily for off-site contractors. The great majority of funding at the National Laboratories is from programs other than CE. The National Laboratories will continue to fulfill the role of providing a strong, focused technology base for CE programs. As such, the National Laboratories will continue to participate in CE programs. It should be noted that the Solar Energy Research Institute (SERI) will continue to serve as a national center for Federally sponsored solar R&D. The SERI mission will continue to focus on long-term, high-risk, potentially high pay-off R&D which private industry cannot reasonably be expected to undertake, and which shows potential.

9. Q. As you know, the Congress has recently received the Sunset Review of the Department of Energy programs as required under the DOE Reorganization Act. This report looked at all of the energy programs presently underway in the Department and made several significant recommendations regarding the future of many of these programs. In many sections of this report, there is no mention of the need to continue various energy research programs well beyond Fy 1983. Do you believe that there is a need to continue these programs in such areas as solar and multi-sector conservation research beyond the FY 1983 timeframe? If not, what are your plans to terminate these programs?

A. Within the general framework of the Sunset Review process and document, we addressed projected activities only in the context of FY 1983. No attempt was made to project beyond that point. We do, of course, believe that there is a need to continue critical research in many of the program areas funded in FY 1983. We are just now beginning the FY 1984 and outyear planning cylce, so it is still too early to address specific plans for termination or continuation.

10. Q. As you are well aware, Mr. Assistant Secretary, there has been a great deal of discussion recently on the Administration's proposed plans to reorganize the Department of Energy. Some people have been disappointed with the President's proposed plan. They believe that the money that can be saved is minimal. Few of the functions of DOE will be actually eliminated under this plan; most will be simply redistributed to other government agencies. Instead, they suggest that we should streamline those areas of DOE that are cumbersome and unresponsive and eliminate those that are unnecessary or burdensome. They also recommend that we keep Energy on a Cabinet level to focus policy decisions, not only in our domestic deliberations but particularily in international negotiations. What impacts will DOE's reorganization have on our Federal conservation and renewable energy programs?

A. Since all Conservation and Renewable programs (including the Power Marketing functions) would transfer intact to the Department of Commerce, the DOE reorganization will have no real impact on these programs.

11. Q. As you know, the Congress has passed several pieces of legislation in the conservation and renewable energy area over the past few years. These include the Solar Research, Development, and Demonstration Act of 1974, the Geothermal R&D Act of 1974, the Wind Energy Systems Act, the Solar Photovoltaics RD&D Act, the Ocean Thermal Energy Conversion RD&D Act and the Energy Security Act. Among other things, this body of legislation calls for several reports describing DOE's program plans in various areas, including wind energy, municipal waste to energy and ocean thermal energy conversion. However, the Committee has not yet received updates, or in some cases, the original DOE program plans as called for in this legislation. Does DOE plan to submit these reports in the near future?

A. As required by Public Law 96-345, Wind Energy Systems Act of 1980, the Department prepared a Comprehensive Program Management Plan for Wind Systems and submitted it to the Congress in November 1981. An annual update, consistent with the President's budget request, is in preparation and will be submitted shortly. DOE is currently completing the Program Management Plan for Ocean Thermal Energy Conversion, as required by the Ocean Thermal Energy Conversion RD&D Act, with submission to Congress scheduled for April 1982. DOE has submitted all documentation required by the Solar Photovoltaic RD&D Act to Congress. DOE plans to submit the reports required by Subtitle B, Title II of the Energy Security Act in the next few months. These reports concern Energy from Municipal Waste and consist of a Comprehensive Plan on the activities to be undertaken and a report on barriers to the implementation of projects. DOE has complied with the reporting requirements of the Geothermal RD&D Act of 1974.

12. Q. The Pacific Northwest Power Planning and Conservation Act requires the Bonneville Power Administration (BPA) to acquire both conservation and other resources in order to meet the net firm requirements of the Pacific Northwest. BPA expects to meet at least half of its FY 1983 power deficit through conservation and the acquisition of non-major resources, primarily renewables and the use of conservation. Over $444 million in borrowing authority is requested for conservation and renewable resources activities in FY 1983. To what extent had DOE considered the impacts of this program in formulating its FY 1983 budget request? Has DOE estimated the impacts of this initiative on the development of new conservation and renewable energy technologies?

A. The BPA approach calls for substitution of funding which might have been needed for capacity expansion. Such an approach is considered cost effective, given the high costs for construction of new capacity. BPA is not the only utility using such an approach to saving money. Funds for implementation of such an approach must be provided by the utility, usually reimbursed through the rate base. Since most of these activities would be applications of known technologies where they are considered cost effective, while the CE budget focusses on more generic research and development, the BPA program had little impact on the formulation of the FY 1983 CE budget. For the same reason, we have done no specific analysis of the impacts of the BPA program on development of new technologies, but would expect such impacts to be minimal.

13. Q. The Department of Energy has requested $15.8 million for multi-sector conservation research for FY 1983. Would you please provide the Committee with a break-out of this funding as it relates to the building and community systems, industry, transportation and utilities areas?

A. The attached chart shows the breakout requested.

Crosswalk of 1983 Ceiling by End-Use Programs

($ in millions)

New Multisector Category	Trans-portation	Industry	Buildings	Energy Systems Research	Total
Heat Transfer and Fluid Mechanics		$0.998	$1.757	$0.475	$ 3.230
Materials and Processes	$2.280		0.330	0.380	2.990
Thermochemical Conversion			0.475	1.897	2.372
Electrochemical Storage and Conversion	5.035			2.185	7.220
Total Program	$7.315	$0.998	$2.562	$4.937	$15.812
Program Direction					1.730
Total					$17.542

82 IND V-1

14. Q. The Department has requested significant cuts in the buildings and community systems and industrial conservation areas for FY 1983. As a result, there seem to be many instances where key program activities already underway will be disrupted. What steps is DOE taking to minimize program disruptions due to these budget cuts? Will industry and the private sector be able to continue these activities and programs without Federal support?

a. In the industrial area, the Committee has heard indications that many industrial participants would simply not be able to pick up the needed remaining costs to complete on-going industrial projects? Do you agree? If not, why not? Will the new R&D tax credits and the new accelerated depreciation tax incentives provide sufficient stimulus to industry to continue these projects? Does the Department plan any new industrial conservation projects in the future in light of their high payoff potential?

b. The GAO recently released a report indicating that the decontrol of crude oil prices would not, by itself, stimulate industrial conservation R&D activities. Do you agree? Do you believe that the Federal government should play a role in supporting high-risk industrial conservation R&D activities?

A. Indications are that the private sector will continue to pursue some of the projects aimed at reducing industrial energy use upon successful achievement of the next major milestone. Some of the remaining work would be accomplished at a slower pace in the absence of government participation. In cases where projects are not considered economical, completion of the work is not envisioned by the industrial participant if Federal support is withdrawn. For all on-going projects, DOE is attempting to complete the next major step before withdrawing, in order to minimize program disruption. It is anticipated that energy-related RD&D

undertaken by the private sector will be substantially increased by the Reagan Administration's economic tax programs. With regard to RD&D activities having industrial energy conservation as their objective, the combination of higher energy prices (resulting from decontrol, e.g.), reduced availability of desired fuels and increased government incentives for investment in RD&D is expected to result in the required private sector initiative. The major criterion determining investment in RD&D by the private sector is risk-adjusted return on investment (ROI).

15. Q. As you know, Mr. Assistant Secretary, the Committee has strongly supported the industrial conservation program in the past. To what extent will the new funding in the multi-sector area for industrial activities complement and supplement prior year activities and projects? Would the Department provide the Committee with a list of project priorities in industrial energy conservation at the $10, $15, and $20 million level?

A. The new funding requested for the multi-sector area includes approximately $1 million of program budget for continued work on advanced industrial heat pump technologies. These technologies promise high payoff but are high-risk, long-term research and development which industry acting on its own would not address. This effort is a continuation of prior year industrial program activities of a similar nature. No additional funds are being sought for industrial conservation technology development because the private sector should now have the incentive and resources to finance such activities. We do not at this time have a list of industrial energy conservation projects that have been prioritized by senior management.

16. Q. What is the status of the DOE/HUD district heating and cooling initiative, the building sciences and technology and consumer product programs? Do you plan to support these programs during FY 1983? If not, what will happen to these various activities (i.e., will the private sector pick up activities in these areas such as generic building research activities)?

A. The initial feasibility studies under the DOE/HUD district heating and cooling initiatives were fully funded using available FY 1981 and 1982 funds. No further DOE funds are requested for district heating. Any of these 28 communities that find district heating attractive may proceed to construct systems. They may choose to use HUD UDAG or Community Development funds for such projects.

There are no funds in the FY 1983 budget for building sciences or technology and consumer products under these end-use technologies. However, some basic research in these areas is continuing under the Energy Conservation Research line item.

17. Q. Is DOE supporting any research in the indoor air quality area to help solve these problems (Urea formaldehyde insulation problems)? If not, why not?

A. DOE has funded research on indoor air quality, not only on urea formaldehyde insulation, but also radon, particulates and other pollutants. The urea formaldehyde problem has been thoroughly described in the record before the Consumer Products Safety Commission. DOE has requested $335,000 for indoor air quality activities in FY 1983. These funds will be used to complete the collection of data on air contamination levels and the evaluation of various control techniques. The work will be done in cooperation with EPA and industry in the expectation that it is more appropriately their concern and that they should pick up future efforts.

18. Q. Title II of the Energy Security Act called for an accelerated research and development program in converting municipal waste to energy. Municipal waste offers an attractive near-term energy resource that can be effectively utilized to make solid, liquid and gaseous fuels, and for electric production. Is the Department carrying out a program in urban waste, and what are the Department's plans in this area in the future? Will DOE submit the comprehensive program management plan required under the Energy Security Act for the municipal waste-to-energy program?

A. The Department is carrying out a program in converting municipal waste to energy in fiscal year 1982, and in accordance with the Department of Interior and Related Agencies Appropriation Act. Since the technology for mass burning of municipal waste to produce steam, and for the recovery of methane from landfills, has been developed, the Administration has requested no funds for the program in fiscal year 1983. The Department will shortly be submitting the comprehensive program management plan required by the Energy Security Act (ESA).

19. Q. The Committee has heard a great deal of testimony about the need for accurate, personalized information on effective energy conservation measures. In light of this testimony, the Committee has supported funding for the Energy Extension Service. Last year, the Omnibus Reconciliation Act required that this program be cost-shared (20 percent) with the States. Do you believe that a well-planned energy conservation information program would be helpful in allowing the marketplace to more effectively carry out its functions?

A. In the energy area, the private sector has done much to disseminate such information. Utilities, trade associations and local and national businesses have responded to consumer concerns with extensive advertising and information exchanges. These are considered sufficient to meet the needs of the marketplace.

20. Q. The Department of Energy recently announced plans to terminate the BACA First Geothermal Demonstration Project. In light of this action does DOE plan to carry out any further activities at the BACA Demonstration site? What does the Department estimate the cost to be for terminating this project? Will the project account contain any unexpended funds, and if so, what does the Department plan to do with these remaining funds?

A. As part of the termination procedures, Union Geothermal will be conducting a limited number of tests on existing wells prior to plugging and abandoning them under State requirements. All partners, including DOE, are sharing the costs of all termination steps. We expect DOE's share of these expenses to be about $2.1 million. Formal reprogramming notifications will be prepared and submitted to Congress for any unexpended funds remaining.

21. Q. As you are aware, Mr. Secretary, the Committee has strongly supported the Second Geothermal Demonstration Project located in Heber, California. This project shows greater merits for helping our Nation tap close to 80 percent of our potentially available geothermal resources. What activities have been completed to date on this project? Will the Department continue to support this project during FY 1982? What are the Department's current total estimated cost for this project? What are the Department's management responsibilities with this project at the present time, and does the Department support any suggestions for reduced management authority in the future if this project were carried forward? What types of reporting requirements are presently contained in the contract between the project participants and DOE; and what information do you believe we will obtain from this project? Is it necessary for DOE to retain the authority to sign off on all major procurements for this project, and has DOE acted in good faith in processing procurement requests?

A. About one-third of the detailed plant design has been completed and long lead-time equipment procurement is about to begin. We will continue our support in FY 1982. The current estimate of total costs are similar to earlier estimates --$122 million, of which $84 million is for design and construction. The Department currently shares management authority with its partners, and feels its role can and should be reduced in the future. Contract reporting requires complete disclosure for use by the industry of plant design, costs, and performance. Under the present agreement, DOE does have the authority to sign off on all major procurements, and we have acted in good faith in processing all procurement requests. Since possible future changes in management responsibility cannot be predicted at this time, DOE's future role in procurement processing has not been determined.

22. Q. The GAO has recently issued a report indicating that the elimination of Federal funds for the Heber demonstration project would impede the full development and use of our Nation's hydrothermal resources. This report also indicated that private industry could not currently undertake this project without Federal assistance due to the project's high technical risks and economic uncertainties. Do you agree? If not, why not? Are there any proposed financial approaches that you are aware of that would help expedite the completion of this project?

A. We do not agree. We believe Federal funding involvement can be ended in FY-82 with project completion thereafter by the private sector. We will work closely with our partners to achieve this end.

23. Q. The HDR program is currently funded at a $10 million level for FY 1982. What activities does the Department expect to complete by the close of FY 1982? Has the Department requested any funding for this program FY 1983? If not, why not? If the Department has not requested any funding for FY 1983, what impacts will this have on our current national obligations with the Japanese and West Germans in the Hot Rock programs?

A. By the end of FY 1982, we expect to have completed a hot dry rock resource evaluation of the United States. This work has been underway since 1977 in cooperation with the Geological Survey. In addition, the first set of multiple fractures for the large, 20-50 megawatt thermal loop at Fenton Hill will have been created. Late in the Fiscal Year we expect to circulate water through the loop on a limited experimental basis.

The budget request for the hot dry rock program in FY 1983 is $2.457 million. The funding will ensure that work at Fenton Hill continues in FY 1983, the final year of our implementing agreement with West Germany and Japan.

24. Q. Many problems currently facing the geothermal industry stem from the inability to accurately assess the extent of geothermal resources and the lack of adequate geothermal drilling systems. More efficient geothermal drilling systems can have significant impacts on the cost of producing geothermal power. The drilling program is closely linked to present industry practices and has under development technology improvements that can reduce the cost of drilling geothermal wells by close to 25 percent. Has the Department requested any funds in resource assessment and drilling activity for FY 1983? If so, how much of this funding will go to support the Sandia program? In addition, is any money included for reservoir drilling activities?

A. The Department has not requested FY 1983 funds for drilling technology, resource assessment or reservoir confirmation drilling.

Drilling research and development activities relating to rock penetration mechanics have already produced important technical advances toward reducing the cost of drilling geothermal wells. Relevant long-term R&D in borehole diagnostics and well completion technology will be continued in FY 1983 to address unresolved problems critical to the efficient and environmentally safe disposal of spent brine (injection technology). These technology improvements are being transferred to the private sector for their use.

25. Q. The Geothermal program has supported the construction of several facilities, including the Raft River Binary Pilot Project and the Geothermal Test Facility in California. Has the Department requested any funding for these facilities in FY 1983? If not, what does the Department plan to do with these facilities?

A. The Department has not requested funding for the Raft River Binary Pilot Project. The Department is considering issuing a Request for Proposal (RPP), soliciting a utility or industry entity to operate the plant at no cost to the government in an R&D mode, to take title to the facilities and equipment, and to restore the site under the conditions of the BLM land use agreement. The Department has not requested any FY 1983 funding specifically for the Geothermal Test Facility (GTF) in California. The only DOE-funded activity at GTF in FY 1983 is expected to be the operation of a geothermal pump test installation for about six months. Maintenance and security for GTF will continue to be covered in FY 1983 by a no-cost contract with Republic Geothermal, Inc. The Department will evaluate plans for decommissioning and disposal of the facility in 1983.

26. Q. The geopressured geothermal program has been subject to much criticism in the past. However, the promise of the geopressured resources is very great, with an estimated resources based of 3,000 to 50,000 quads. What funding is requested in this area for FY 1983 and what activities will be supported with this funding? What does the Department plan to do with the wells which have been supported in this program in the past?

A. The budget request for the geopressured geothermal program in FY 1983 is $2.44 million. The funding will be used to conclude production testing of the four design wells. The test results will provide the data industry needs to do a preliminary economic assessment of the geopressured resource. Upon completion of testing, the design wells will either be plugged and abandoned in accordance with applicable state regulations or turned over to an industrial operator for long term production. In the latter case, we expect to continue to obtain production data for the lifetimes of the wells at no additional cost to the government.

27. Q. The Committee has heard in the past about numerous environmental control problems associated with geothermal energy development. The most pressing environmental problem in the past has been hydrogen sulfide abatement, but this has just been one of several problems. Does the Department plan to fund any environmental control activities for FY 1983, and if so, in what areas?

A. In FY 1983, long-term research will be conducted to evaluate techniques for monitoring the subsurface movements of injected fluids; to identify measures for preventing the pollution of groundwater by injected brine; and to evaluate special emission control problems associated with liquid reservoirs.

95-882 O—82——42

28. Q. The Department of Energy has not requested any funds for the active and passive solar energy program for FY 1983. Will this action still allow for the orderly termination of program activities in this area? Will the currently available tax incentive for active solar systems provide sufficient incentives to stimulate the use of these systems in the future? Does the Department support the extension of these credits?

a. In accordance with legislation passed by the Science Committee, the Department has funded many solar demonstration projects using both active and passive systems. The purpose of this initiative was to obtain valuable operational data that will help educate the public on the benefits and costs of solar systems. The Committee has been concerned that data collection has been relatively slow, and it is doubtful that much of the information collected is reaching the target audience. Has the Department taken steps to correct this problem? Will the Department continue to collect operational data from these experimental projects in the future?

A. Funding available to the active and passive programs in FY 1982 will allow completion of activities in an orderly fashion. We believe that the deregulation of oil and natural gas, in combination with available Federal and State tax incentives, will be sufficient to stimulate the use of active and passive solar energy systems in 1983 and beyond.

The Committee's concerns over timeliness of data collection have been rectified this fiscal year, and we are continuing to collect operating data using FY 1982 funds.

29. Q. In the photovoltaics area, would you please give the status of the following:

a. on-going experimental projects, including the Georgetown project, the PRDA's and the residential experiment stations;

b. the balance-of-systems program;

c. the Low-Cost Solar Array program;

d. the SMUD project;

e. uniform performance criteria and test standards activities.

Will any funding be requested in these areas for FY 1983? Given the Department's future photovoltaics program plans, do you believe that we will be able to meet the photovoltaics cost and production goals set out in the Solar Photovoltaics RD&D Act?

A. The location, size and operational data of projects are indicated below. Operational projects are instrumented and continue to provide valuable data to the photovoltaic (PV) program. All completed projects will continue to be operated, and data analyzed, at least through the end of FY 1982 and in most cases into FY 1983.

Project	Size (KWp)	Operational Date
Intermediate Size:		
Dallas-Ft. Worth Airport, TX	27.0	July 1982
BDM Bldg., Albquqerque, NM	47.0	April 1982
Wilcox Hospital, Kauai, HI	35.0	January 1982
Sky Harbour Airport, Phoenix, AZ	225.0	June 1982
El Paso Electric, TX	15.5	January 1981
Oklahoma City Science and Art Center	135.0	March 1982
Shopping Center, Lovington, NM	90.4	March 1981
High School, Beverely, NM	90.4	April 1981

Light Mfg. Facl. San Bernardino, CA	35.0	September 1981
Mt. Laguna, Radar, CA	65.0	August 1979
WBNO Radio, Bryan, OH	15.3	August 1979
Agricultural, Mead, NE	29.3	July 1977
Natural Bridges, UT	105.3	June 1980
Miss. Cnty. Comm. College, AR	240.0	April 1982
N.W. Miss. J.C., MS	101.0	N.A.
Soleras, Saudi Arabia	300.0	December 1981
Georgetown University, DC	300.0	April 1985
Sacramento Municipal Utility, CA	1,000.0	July 1984
Size (Residences)		
John F. Long House, AZ	4.9	May 1980
Florida Solar Energy Center, FL	5.0	August 1980
Northeast RES, MA	25.5 (5 Systems)	July 1981
Southwest RES, NM	37.8 (8 Systems)	September 1981
Southeast RES (Site not selected)		
Carlisle, MA	7.1	February 1981
Hawaiian Islands	8.0 (3 Systems)	June 1981
Small Size (Village Power)		
Indian Village, Schuchuli, AZ	3.5	December 1978
Small Size (Military Radar)		
Naval Center, China Lake, CA	8.1	March 1977

In recent months several areas of the balance-of-systems program have reached completion with the publication of final reports. Examples are optimized designs for low-cost ground-mounted structures, low-cost erection techniques, a low-cost electrical wiring scheme, a number of regionally-specific PV residential designs; and advanced designs of residential and intermediate power conditioning equipment. Those areas still requiring work--mainly in the power conditioning area--will be completed with the funding provided in the FY 1982 budget.

The Low-Cost Solar Array project--now called the Flat-Plate Solar Array project (FSA)--has been modified to transfer responsibility for very near-term activities to the maturing photovoltaic industry and to maintain Federal support for longer-term, high-risk research in the project. Technology transfer for some of the near-term goals has been completed, and it is expected that industry will pick up the newer technology as feasibility is demonstrated for the high risk elements.

The Department is expected to award $6.8 million to SMUD sometime in early summer for the construction of a 1 MWp photovoltaic power plant. SMUD will contribute $3.2 million and the California Energy Commission will contribute $2.8 million. This plant is expected to be completed 24 months after award and will provide operating information necessary for SMUD to decide whether to proceed to a full 100 MWp plant.

The uniform performance criteria and test standards activities have essentially been eliminated from the photovoltaic program since industry has successfully assumed this responsibility through several industrial association standards groups.

Regarding the cost and production goals of P.L. 95-590, as our report "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems," February 1980

(prepared in response to Section 10 of the Act) previously indicated, it is not probable that production doubling and $1/Wp systems could be achieved by 1988, even assuming the 10-year, $1.5 billion program authorized in the Act. The program proposed in FY 1983 is designed to address the most critical research questions that need to be answered to produce low-cost photovoltaic systems rather than trying to meet specific production and cost targets at some future time.

38. Q. According to the Hollifield charts provided to the Committee, the DOE Assistant Secretary originally requested $48 million for the solar photovoltaics program for FY 1983. However, the formal Administration request calls for $27 million in this area. Why was this progam cut so dramatically, and what additional activities would have been funded at the $48 million level?

A. The Assistant Secretary request of $48 million for solar photovoltaics was a preliminary internal budget request made in the summer of 1981. The details of this request were scrutinized very carefully in terms of industry requirements and cost-effectiveness. After reviewing the status of the industry and the areas of research in greatest need of continued Federal support, a number of activities were reduced in scope or eliminated from the budget request. Activities not in the $27 million budget that would have been funded at the $48 million level include:

1. $3 million for greater efforts in silicon materials purification. These are no longer needed in light of successful negotiations with Union Carbide Corporation permitting this research to be completed at a substantially lower level of Federal involvement.

2. $6 million for additional research and development funding for semicrystalline and other silicon ingot technologies and further development of silicon ribbon technologies. This level of funding is no longer necessary due to successes achieved by the private sector, particularly Solarex and Westinghouse, in these areas.

3. $5 million for further development of balance-of-system components to provide cost-effective technology to deal with PV systems/utility interface issues. This work is no longer needed due to successes achieved in FY 1981 and those expected in FY 1982.

4. $6 million to continue design and testing of advanced PV module and systems concepts, including additional experiments at the Residential Experiment Stations. These activities are not required due to funding support provided in FY 1982 for SMUD and the SE residential experiment station.

5. $1 million for capital equipment in support of research and development efforts.

31. Q. Several reports have recently been released which have commented on the future and direction of the DOE photovoltaics program. These include the recommendations of the Solar Photovoltaics Advisory Committee and industry strategy report. Does DOE agree with the findings and strategies in these reports? To what extent has DOE followed their advice in formulating its FY 1983 program?

A. In general, DOE agrees with the findings and strategies in these reports and has implemented, or is in the process of implementing, most of them.

32. Q. Please give the status and requested funding in FY 1983 for the following:

a. The Solar One, 10 MW Central Receiver Solar Thermal Pilot Plant.

b. The small community engineering experiment project.

c. The Central Receiver Test Facility.

d. The Solar total energy experiment at Shenandoah, Georgia.

e. The solar repowering program.

f. Activities relating to the Stirling receiver/engine for parabolic dish electric systems.

A. a. 10 MW Central Receiver Solar Thermal Pilot Plant. Physical construction of this pilot plant is complete and the facility is undergoing checkout in prepration for experimental operation. Negotiations are underway with the Southern California Edison Company, to transfer ownership of the DOE-funded portion of the pilot plant to the utility. $9.5M is requested for FY 1983 to provide for completion of automatic control software, operation, maintenance, data collection and evaluation for one year.

b. In the case of the small community engineering experiment, plans for expenditure of funds appropriated are being developed. No funds are requested to carry it forward in FY 1983.

c. The Central Receiver Test Facility has been operational since early 1978, and is now being worked to test a cost-shared liquid sodium receiver experiment. Experimental activity will be completed in mid-1983 based on available FY 1982 funds. No funds are requested for FY 1983 to support operation beyond that point.

d. Phyical construction of the solar total energy experiment is complete and the facility is undergoing checkout in preparation for experimental operation. Negotiations are underway with the Georgia Power Company to transfer ownership of the experimental system to the utility. No FY 1983 funds are requested.

e. The solar repowering program has funded a number of conceptual site-specific designs of utility, industrial heat and cogeneration retrofit applications for solar central receivers. These designs have been evaluated and documented. No funds are requested for further site-related activity in FY 1983.

f. Development of a receiver/Stirling engine subassembly has been completed, and testing of this component is underway at the Parabolic Dish Test Site at Edwards Air Force Base. An industrial team has been selected to cost-share the development of a concentrator/receiver/engine module with full automatic controls. No funds are requested for further work in FY 1983.

33. Q. According to the Hollifield charts for FY 1983, the DOE Assistant Secretary-recommended level for solar thermal in FY 1982 was $39.5 million. However, the administration has formally requested only $18 million for the solar thermal program for FY 1983. Why was this cut made from the Assistant Secretariat level, and what additional activities would be funded at the $39.5 million level?

A. The reduction from $39.5M to $18M eliminated technology development activities that are not appropriate for Federal sponsorship. These include efforts in central receiver, paraolic dish, parabolic trough, solar pond and thermal storage technology. Elimination of these activities made it possible then to eliminate funds for operation of test facilities to evaluate the industrial designs. Also eliminated were certain categories of research which sought to expand the applicability of solar thermal technology beyond early applications, such as process heat and electric power generation. These activities, e.g., production of fuels by thermochemical processes, are considered speculative and relevant only when a viable concentrating collector industry emerges.

34. Q. The Solar One pilot project is scheduled to be initially operated in FY 1983. How long is this project scheduled to be operated, and what are DOE's long-range plans for disposition of this project? Has DOE entered into any negotiations with Southern California Edison Company regarding final disposition of this project?

A. Negotiations are underway with the Southern California Edison Company to transfer ownership of the DOE funded portion of the pilot plant to the utility. The funds requested for FY 1983 provide for the first year of a five-year phased program of experimental and power generation operation. The existing cooperative agreement with Southern California Edison provides for disposition by mutual agreement at the end of 5 years. It is DOE's desire to complete negotiations with the utility within a few months and to transfer ownership in early FY 1983.

35. Q. The solar thermal program has developed a set of cost-performance objectives. These include the following:

- o industrial process heat - $9 to $11 per million BTUs by the early 1980s
- o total energy/congeneration - $1,000 per kilowatt by 1983-84
- o utility electric power - $1,300 per kilowatt-electric by 1985-87

How far has the progam progressed in meeting these goals? Do you believe that these goals will be met within the timeframe specified? What impact will the business energy tax credit of 15 percent and the investment incentives contained in the Economic Recovery Act of 1983 have on DOE's ability to meet these goals?

A. The cost of solar thermal systems that could be deployed today, without further technolgy development and in the absence of cost/price reductions achievable through mass production of components, would be a factor of 2-4 higher than the goals. Costs projected for concentrators mass-produced according to designs validated in the program to date are about a factor of 5 less than concentrators (heliostats) deployed 5 years ago. Further progress is possible based on innovation in the private sector. Similarly, costs projected for initial commercial industrial heat, utility electric, and cogeneration installations, which present favorable economics now as a result of the availability of tax credits and other temporary incentives, are a factor of about 5 lower per-unit-of-energy-produced than early pilot plants, but still a factor of 2-4 more costly than the referenced goals.

DOE does not expect this goal to be met in the stated timeframe. For this to happen would require excessive Federal expenditure in support of projects and technology development which, in time, the private sector may elect to undertake. The business energy tax credit is being proposed for elimination, so is not expected to be available for such projects.

The solar thermal technologies can not yet be classified as being fully commercially available. Although some limited sales are occurring, further research and development must be completed before wide scale deployment can be expected. Accordingly, the provision of sizable tax credits for increasing levels of corporate R&D investments represents the most significant provision of the Economic Recovery Tax Act with regard to the immediate future of the solar thermal technologies. Due to the newness of this incentive, the Department has no basis for determining the impact upon accomplishment of the referenced goals.

36. Q. One of the solar thermal technologies which has received attention in the past is the solar bowl technology. How does DOE rank this technology in terms of promising solar thermal technologies? Does DOE believe that it would be appropriate to pursue the continued development of this technology in light of current budget constraints?

A. The hemispherical bowl concept is one of several concentrating heat collector concepts that have been evaluated on a comparative basis in the context of applications up to 10 megawatts in scale. The results of these comparative evaluations have been mixed, with the hemispherical bowl showing no clear advantages over other heat collection concepts with similar capability. In spite of the optimistic assumptions regarding the cost of the bowl concentrator, none of the studies have indicted that cost savings related to the fixed structure of the bowl concept would overcome the intrinsic annual performance disadvantages of a non-tracking collector. It should be noted, however, that these studies have assumed applications within the continental United States, while the stationary concentrator has better performance potential in equatorial regions.

Nevertheless, the results of the independent comparative analyses must be regarded as inconclusive, since they were based on designs that lacked maturity and for which there was not adequate detail from which to base firm

cost estimates. The hemispherical bowl differs significantly from other concepts in terms of its modularity, range of temperature capabilities, and a variety of design features that would affect product cost.

In the face of substantial uncertainties about key factors that would condition the market for solar thermal systems in the future, an effort to bring hemispherical bowl technology to the same point of technological readiness for commercialization would offer marginal benefits in relation to the objectives of the Department of Energy's Solar Thermal Program. In particular, it is considered legitimate to carry the bowl concept to the same point of development as parabolic dishes, parabolic troughs, and central receivers (Shenandoah, Coolidge, and Barstow). This would involve the design, fabrication and testing of a single subscale energy-producing module placed in a user environment. To go further than this would be inconsistent with policies established by the administration and approved by the Congress in their action in our FY 1982 budget request.

37. Q. A recent ERAB panel report contained several significant conclusions including the following:

a. At present in the United States, the fuel supplied by biomass is about 1.2 Q (net), or nearly 2% of the total U.S. energy consumption of 78 Q (gross). By the year 2000, with appropriate research and development, biomass has the potential of supplying the nation with about 5 Q (net) or about 5% of projected U.S. energy consumption (100 Q).

b. Biomass resources have the distinct advantages of being a renewable energy source and, in some areas, being a locally abundant resource (e.g., fuel wood).

c. Biomass energy potential is primarily constrained by limits on agricultural and forest production and by the need to maintain a productive, high-quality environment.

ERAB research recommendations emphasized biomass production from forest and agricultural lignocellulosic materials because these are the major biomass resources available in this country. Priority was given to research on biomass production instead of conversion technologies because the quantity of biomass resources is a major limitation in this program. Do you agree with these findings? If so, why is the biomass budget request so heavily weighted toward the conversion side of the program?

A. We agree that biomass has the potential of contributing to energy production in the U.S. Current activities in the DOE Biomass Program in short-rotation woody and herbaceous crops will provide industry with the information it needs on production, as a basis for development and commercialization. Basic understanding of the mechanisms for converting biomass reesources to gaseous and liquid fuels are lacking, hence, the emphasis is being placed in this area for FY 1983.

95-882 O—82——43

38. Q. The Energy Security Act requires the Departments of Energy and Agriculture to prepare a comprehensive report on biomass energy development. Has this report been prepared? If so, could the Committee obtain a copy?

A. The Energy Security Act requires a plan covering the production of alcohol fuels and fuels from biomass. This plan is being drafted in coordination with the Office of Alcohol Fuels and the U.S. Department of Agriculture. The draft plan is undergoing review prior to submittal to Congress.

39. Q. The Departments of Energy and Agriculture have both been involved in the biomass program in the past. How closely are the Departments working together in this area, and is their work covered by a Memorandum of Understanding between the two agencies? Will any DOE funding be "passed through" to USDA during FY 1982 and FY 1983?

A. The U.S. Department of Energy (DOE) and U.S. Department of Agriculture (USDA) signed a Memorandum of Understanding on October 30, 1978, and an Interagency Agreement was signed in April 1980 for a biomass energy development program. This agreement assigned technical management responsibility for on-farm energy systems, herbaceous crop development and near-term silviculture activities to USDA. DOE ensured that these activities were integrated into the overall DOE Biomass Energy Programs. Overall planning for the direction and strategy of these activities was carried out jointly by DOE and USDA. In addition, USDA and DOE interacted through joint site visits, meetings, and exchange of information. FY 1982 funds are being provided to USDA for the joint USDA/DOE herbaceous crop development activities. No funds will be provided to USDA in FY 1983, since these biomass energy activities will be completed in FY 1982.

40. Q. The feedstock development element of the biomass program has focused on several areas, including short-rotation woody crops, herbaceous energy systems, and aquatic biomass energy systems. However, the Department has requested funding for only aquatic systems activities in FY 1983. Would you explain the reason for this funding action? How would you rank these feedstocks in order of development priorities?

A. Current research activities in short-rotation woody and herbaceous crops will be completed and will provide the information needed by industry to proceed with development and implementation. Research for aquatic systems, particularly microalgae concepts, is in an early phase and will therefore continue in FY 1983 because of its potential high-payoff. FY 1983 R&D activities in suport of microalgae energy development will examine innovative approaches involving genetic manipulation techniques to enhance the ability of microalgae to grow in specialized environments and produce greater quantities of high quality oil.

41. Q. The conversion technology element of the biomass program has focused its efforts on thermochemical conversion technologies, biochemical conversion technologies, and photobiological systems. What accomplishments have been achieved in each of these areas? Would you please tell the Committee the status of the thermochemical PDUs?

A. In the thermochemical conversion area, DOE has: a) proven technical feasibility of oil production from woody biomass; b) shown, with preliminary technoeconomic assessment, that medium-Btu gas can be produced at $4.00/million Btu's; c) shown feasibility of direct firing of wood in a gas turbine and d) successfully operated a multi-solid fluid bed gasifier without requiring an oxygen plant. Progam evaluations of a variety of high performance gasification systems for producing medium-Btu gas and synthesis gas will be completed in FY 1982, since further development can be left to private industry. In the biochemical conversion area, an anaerobic digestion system for cattle manure was developed and turned over to the private sector. Furthermore, within the range of 50-500 head of dairy cows, biogas has proven cost-effective in comparison to propane or fuel oil. The program on photobiological production of hydrogen research area has focused research efforts on biological systems that yield hydrogen for several days at pressures up to 700 psi. In vitro cell-free systems have also been developed with high photo-efficiency.

Five process development units (PDU's) ranging in size from 0.5 to 25 tons/day are operational at this time and will be yielding significant data in FY 1982 on the production of medium-Btu gas and synthesis gas from woody biomass. One additional PDU of pressurized, oxygen-blown, fluidized-bed design is scheduled for start up in FY 1983. In the area of liquid fuels production, SERI is examining a bench-scale PDU for fast pyrolysis. This PDU will be tested over the next few years and should yield important information concerning this innovative, high-risk technology. The PDU stage allows key process features to be tested and evaluated in a continuous mode while optimizing some process parameters and obtaining material and energy balances. Following PDU testing of gasification in FY 1982, it is anticipated that the private sector will assume major responsibility for process scale-up where economic.

42. Q. Please discuss the extent and nature of industrial involvement in the DOE biomass program. What problems does industry face in participating with the Department in this area?

A. The Department of Energy has had a good working relationship with private industry in the development and direction of the biomass program. Since the full market penetration of biomass energy systems will be accomplished by the private sector, DOE has sought industrial involvement in the planning and execution of fundamental research on promising biomass technologies. Industry has become involved in the basic R&D process by participating in contracts with the national laboratories, which serve as field managers for the major biomass program elements. Individual program elements, such as aquatics and thermochemical conversion technology, have received substantial interest from the private sector. Private industry has performed useful engineering feasibility studies and economic assessments on promising thermochemical processes and aquatic production systems. DOE will continue to seek the advice of industry in the planning and execution of biomass program activities.

43. Q. Wood has been recognized as a biomass resource with much promise for providing a portion of our Nation's future energy needs. What activities are planned in FY 1982 to utilize this resource to produce energy?

A. During the last decade, rising oil prices have brought about increased interest in wood fuel use for industrial and home heating applications. Many U.S. companies are involved in the marketing of commercial direct combustion and low-Btu gasification equipment. The private sector will pursue further development of wood energy systems as the price of natural gas is deregulated. There has been substantial progress in medium-Btu gas generation using multi-solid fluidized-bed technology. DOE is continuing to support high-risk research on thermochemical processes that produce fuels from woody feedstocks at competitive costs. FY 1983 thermochemical research activities will concentrate on fast pyrolysis techniques for liquid fuels production, direct liquefaction techniques for the conversion of woody biomass to liquid fuels, and gasification technology for the conversion of woody biomass to gaseous fuels. Advancements in these basic research areas will provide additional incentives to industry to make use of the country's abundant wood resources.

44. Q. To what extent are activities in the biomass program coordinated with activities underway in foreign countries such as Brazil?

A. The Biomass program is involved with International Energy Agency (IEA) biomass activities undertaken to help IEA countries obtain stronger national energy production capacities, thereby reducing the cost of their oil imports. DOE biomass staff participate in two IEA Implementing Agreements which promote international cooperation in the fields of forestry energy production and biomass conversion technology. Participants in IEA forestry energy projects include the United States, Austria, Belgium, Canada, Denmark, Finland, Ireland, New Zealand, Norway, Sweden, Switzerland and the United Kingdom. The IEA forestry energy research program focuses on the use of short-rotation forestry biomass and forestry residues to produce clean fuels and petrochemical substitutes. DOE also participates in the IEA Biomass Conversion and Technical Information Service, which provides participating members with scientific and technical data relevant to research, development and demonstration activities concerning numerous biomass conversion projects. The Biomass Conversion Service

is operated by the government of Ireland acting through the National Board of Science and Technology of Ireland. Participants in this IEA program include the governments of Austria, Belgium, Canada, Portugal, West Germany, Ireland, Italy, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom and the United States.

The government of Brazil is sponsoring research on a number of biomass technologies including the production of ethanol from woody biomass, short-rotation intensive culture, anaerobic digestion and herbaceous crops development for the production of diesel fuel substitutes. DOE staff remain cognizant of Brazilian biomass energy activities through the exchange of technical information and through occasional visits with scientists and officials from Brazil.

45. Q. The Department has requested $3 million for the alcohol fuels program for FY 1983. How much of this funding will be used for advanced process technology development activities, especially relating to acid and enzymatic hydrolysis activities? Will this program continue to be managed by SERI? How much funding will SERI receive in this area for FY 1983?

A. Of the $3 million for alcohol fuels requested for FY 1983, $2.9 million or about 97% will go to advanced process technologies. Acid and enzymatic hydrolysis activities will comprise $2.4 million or 80% of the budget. This program will continue to be managed by SERI and they will receive approximately 90% of the budget, $2.7 million, to do so.

46. Q. How are the funds for alcohol fuels research split between activities relating to the development of ethanol and methanol? How closely does the Office of Alcohol Fuels work with the Fossil Fuels Division in developing methanol resources?

A. In FY 1983, $2.4 million will go to ethanol development and $8.5 million will go to methanol development. The Office of Alcohol Fuels (AF) coordinates its methanol development work through the Biomass Energy Coordinating Committee. The two program offices are aware of the work that the other does. The two fossil fuels groups that work on coal gasification and liquefaction are dealing with large scale technologies to produce methanol, as well as other products, while AF has a small scale biomass fueled gasifier to produce synthesis gas for conservation to methanol.

47. Q. Is the Department of Energy coordinating its efforts in alcohol fuels with the research and pilot program in the Depart of Agriculture?

A. Yes, the U.S. Department of Agriculture is a member of the Department of Energy's Biomass Energy Coordinating Committee and the Office of Alcohol Fuels does have an interagency agreement with the Department of Agriculture, under which Alcohol Fuels is providing funds to two of their main R&D labs for alcohol research.

48. Q. Alcohol fuels has been suggested as one of the "alternative energy sources" which might be available fairly soon, if properly developed. When does the Department of Energy think these fuels might be available in significant quantities? Does DOE believe we be able to meet the production goals for alcohol fuels set forth in the Energy Security Act?

A. The Energy Security Act sets two goals for alcohol fuel production in the United States. The goal for December 31, 1982, is 60,000 barrels of alcohol a day, or 920 million gallons a year production capacity.

The long-term goal is 10 percent of domestic gasoline consumption by 1990. The Energy Information Administration has estimated the consumption of gasoline in the U.S. to be about 84 billion gallons in 1990. Based on this level of gasoline use, the goal amounts to an annual U.S. production capacity of 8.4 billion gallons in 1990. Recent trends in oil, biomass feedstock and by-product prices make it unlikely that either goal will be met.

The elimination of large Federal subsidies for conventional fuels enhances the competitive position of alcohol fuels. However, the penetration of alcohol fuels into the market should be predicated on free market prices and rational private sector decision-making. By using the signals of the price system, alcohol fuels will enter the market at a rate commensurate with its ability to compete with other fuels in the long run.

49. Q. Does the Department of Energy believe that we need more testing to accurately assess the advantages and disadvantages of gasohol and other types of alcohol fuels/gasoline blends? If so, what sort of testing program could be required?

A. Yes, DOE does believe that more testing is necessary to accurately assess the advantages and disadvantages of various types of alcohol fuels and gasoline blends, such as dissociated alcohol and methanol. Further gasohol testing is not considered necessary. It is possible that ethanol and methanol can be effective and economical octane boosters in formulations as yet undeveloped. Such testing is considered product development and should be done by the private sector. In fact, major oil companies are conducting such activities now.

50. Q. The Department of Energy is currently supporting its alcohol fuels program FY 1982 at a $10 million level. What will be the impact of the proposed budget request for FY 1983, which cuts this program back to $3 million?

A. The budget cut-back should have only minimal impact. The Office of Alcohol Fuels is finishing up the development of a two year plan for FY 1982/83 which will minimize the impacts of the 70% cut by cutting out work that is too near-term and by centralizing the entire R&D program at SERI. Since SERI has been the focal point of the R&D program, this plan will allow us to concentrate on production technology goals as we close out the program.

51. Q. The Department recently announced its intention to enter into negotiations with 11 project teams for loan guarantees assistance to support the commercial production of alcohol fuels. What is the status of these negotiations?

A. In August 1981, we selected eleven firms for conditional commitments for alcohol fuel loan guarantees. Since that time, one company has decided to withdraw from the program. Negotiations with the remaining ten companies are continuing and should be completed by early summer. These negotiations, if successful, will facilitate the construction of plants with a total annual capacity of 350 million gallons of anhydrous alcohol.

52. Q. What other Federal agencies are assisting in lending expertise to DOE in the OTEC program in FY 1982 and FY 1983? In what ways and to what levels of effort?

A. Two other agencies are involved in the ocean energy technology program: the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), and the Department of Defense (Navy).

DOC-NOAA is managing ocean engineering development for DOE. This includes cold water pipe research and testing, mooring systems and platform development, and foundations research. The FY 1982 funding being allocated to NOAA for these tasks is $5.0 million. The DOD-Navy is managing geothermal OTEC conceptual studies and ocean energy products development for DOE. The FY 1982 funding allocated to Navy laboratories for these tasks is $1.1 million.

There is no funding requested for the ocean energy program in FY 1983.

53. Q. What is the status of the research to date regarding the following:

a. Light-weight concrete construction technique for OTEC platforms.

b. Alternate designs for modular experiments and large commercial systems.

c. Coldwater Pipe Development.

d. Electric transmission cable development.

A. a. DOE has not investigated the construction technique for light-weight concrete shelf-mounted platforms. However, the John Hopkins University/Applied Physics Laboratory designed a light-weight concrete coldwater pipe (CWP). Light-weight concrete sections were fabricated by Portland Cement Association and the concrete sections were tested by Concrete Technology, Inc. Previously, light-weight concrete has been used for the construction of ships, and is presently being evaluated by the industry as a material for the OTEC shelf-mounted platform.

b. Two modular experimental conceptual designs are being awarded. One design addresses a land based plant with a bottoming cycle option, and the second design uses a shelf-mounted structure on a 30-degree sloped ocean bottom. With reference to commercial systems, DOE has completed baseline designs, cost estimates and analyses for a 400 MW commercial size platform plantship and for a 200 MW moored floating platform. These design studies have been the basis of most of the OTEC cost projections.

c. The OTEC-1 platform, which was deployed for heat-exchanger experiments, used a cold water pipe that was made up of a cluster of 3 sections of 4' diameter polyethylene, 2,850 feet long. This pipe was assembled and used from mid-December 1980, through the end of April 1981, to provide deep cold ocean water in both moored and grazing configurations. At present, Hawaii Dredging and Construction Company is conducting a 10-foot diameter, cold-water, pipe at-sea test program under a DOE/NOAA contract. The pipe is being constructed with a fiber-reinforced plastic skin and a synthetic foam core, and is instrumented to provide data on loads and motions.

d. No electrical problems are anticipated for bottom-laid electrical cables. For riser cables, extensive development work has been conducted to ensure survivability under strenuous, sea-enduced motions. Ten full-size cable samples have been manufactured and are being tested by simulating handling, installation and operation in the OTEC environment. Test results indicate that several polethylene insulation and oil-filled insulation cables have suitable electrical characteristics. The polyethylene insulation cable also appears to have appropriate mechanical properties.

54. Q. There has been much discussion on the promise of OTEC energy systems as a viable long-range energy resource. Has DOE completed any studies on the possible energy contribution from OTEC systems in the future?

A. From a global standpoint, OTEC could represent a substantial increment of world energy supply. The DOE has completed a number of reports on the availability of the OTEC Thermal Resource around the world. OTEC Thermal Resource reports are available through the National Technical Information Service (NTIS) for Florida east coast, Western Gulf of Mexico, Hawaii, Central Gulf of Mexico, Ivory Coast, Sri Lanka, Pacific Plant Ship, Mombasa, Western Coast of Mexico, Dampier Land, Australia, Guam, Manila, Phillipine Islands, Jakarta, Indonesia, and Caribbean Sea Plant.

The market potential for OTEC products other than electricity has been examined by GE Tempo, DSS Engineers, and by the Applied Physics Laboratory of the John Hopkins University. The products examined include aluminum, ammonia, hydrogen, chlorine, and synthetic fuels (methanol) from coal. Also, the Institute of Gas Technology (IGT) has studied the production costs of chemical-energy carriers such as ammonia, hydrogen, carbonaceous fuels (such as methanol), of refining lithium for lithium-air batteries, and of thermal-energy carriers such as molten salts.

General Electric Tempo in their reports, "OTEC Mission Analysis Study, Phase I and Phase II," arrived at three possible OTEC implementation rates for high, intermediate and low market penetrations.

The actual energy contribution that OTEC may make in the future is dependent on the actual performance and economies achieved by OTEC systems vis-a-vis the cost and other factors relative to energy sources.

55. Q. The Department has recently announced its intention to enter into negotiations with two Hawaiian project teams for the conceptual design of an OTEC pilot project.

a. When does DOE expect these designs to be completed?

b. Does DOE plan to obligate the $4 million deferred in FY 1982 in FY 1983 for the preliminary design of OTEC pilot projects?

A. a. We anticipate contract start dates of April 1, 1982, with Phase I conceptual designs expected to be completed by March 31, 1983.

b. Yes.

56. Q. The Department of Energy has funded eight large wind turbines in its wind energy program. What is the status of these intermediate and large-scale wind systems?

Does the Department plan to continue to support the operation of these machines during FY 1983? If not, why not?

Will any of these machines be dismantled or destroyed, or will any be refurbished and turned over to private utilities?

Specifically, what are the Department's plans for operating the MOD-2 wind cluster, and is any funding provided in FY 1983 to continue the operation of this project? If not, why not?

A. The testing on the MOD-1, 2000 kilowatt machine in Boone, North Carolina has been completed and plans for disposition of the machine are being finalized. Testing on the four 200 kilowatt MOD-0A's in Rhode Island, New Mexico, Puerto Rico and Hawaii will be completed this summer. All MOD-0A's will have completed more than two years of tests. These machines have supplied three million kilowatt hours of electricity to the local communities. The host utilities will be invited to continue operation of the machines.

The Department is not requesting FY 1983 funds for continued operation of the MOD-0A, MOD-1 and MOD-2 machines. While these machines played a key role in the development of large wind turbine technology, they are no longer needed in our research program.

A plan to examine disposition options for each machine is now being developed. Dismantlement is an option that is being considered.

The Department plans to complete acceptance, initial operational, and research tests of the MOD-2 cluster in FY 1982. Discussions are underway concerning transfer of the machines to the host utility, Bonneville Power Administration, for FY 1983. No funding is requested for routine operation of the turbines beyond FY 1982.

57. Q. As you know, the Committee authorized funding in FY 1982 for the MOD-5 Wind Energy Program. What is the status of the program?

Does the Department believe that it would be necessary to continue to support this program through the detailed design phase before the private sector would pick it up?

What is the Department's evaluation of the current non-Federal efforts to develop and operate cost-competitive large wind machines?

Based on this private sector activity, does DOE believe it is necessary to support the MOD-5 program in FY 1983?

A. The FY 1982 budget included $15 million for continuation and completion of preliminary designs and related engineering support for the MOD-5 project by the two contractors, Boeing Engineering and Construction and General Electric. Advanced features associated with the MOD-5, such as variable speed operation and advanced yaw and rotor tip control algorithms, are being tested and validated by NASA.

The Department believes that completion of two fully-documented preliminary designs of potentially-commercially-viable MOD-5 concepts will provide sufficient impetus for the private sector to continue development if the results of these concepts show economics and risks commensurate with acceptable business practices.

The Department believes that ongoing, non-Federally-funded ventures to develop wind systems are evidence that past government programs have accomplished their initial aims; that private industry is beginning to develop large wind systems as private ventures; and that the federal role should now focus on technology-based research. Thus, we do not believe that it is necessary to continue to support the MOD-5 program in FY 1982.

58. Q. Would you please tell the Committee how much funding is being obligated at Rocky Flats for the wind effort there during FY 1982?

How much funding is being requested for this activity for FY 1983?

A. Funding to be obligated at Rocky Flats in FY 1982 is $4,490,000. The programs accomplished by Rocky Flats have played a catalytic role in the development and evolution of the small wind turbine industry. These programs have been successful, with approximately 40 companies now marketing small machines. As a result, we see a decreasing need for continued operation of the test center at Rocky Flats. Detailed plans are currently being developed for phase out of Federal support, so no funds are requested in FY 1983 for this activity.

59. Q. Has the Department conducted any analyses or studies on the effects of the PURPA regulatory incentives on the development of wind energy power?

If not, does the Department plan to conduct any in the future?

If the Department has, have these conclusions been factored into the Department's budget request for wind systems?

A. The Department has not conducted any specific in-depth analyses of the effects of PURPA on the use of wind energy. The small power producers provisions are generally considered to increase the prospects for use of all types of renewable energy systems for power generation, including wind energy. The impetus for wind farm development in States such as California, Hawaii and New Hampshire can be partially attributed to PURPA. The Department has no plans to fund such studies in the future.

60. Q. The Committee has heard about several significant problems with the development of wind energy systems, including stress and fatigue failure problems and noise interference problems. What is the Department's evaluation of these problems?

Has the Department requested any funding in FY 1983 in these areas?

A. Several of the large and small machines being field-tested by DOE have encountered structural problems relating to stress and fatigue. In some cases the loads encountered during normal operation or under extreme storm wind conditions are higher than those predicted by theoretical models. Some of the problems were attributable to not adequately addressing environmental considerations in the design of prototype machines. For example, a blade root mounting stud on the 200 kilowatt MOD-OA experimental machine in Hawaii failed after 7,800 hours of operation. Careful analysis of the problem showed that corrosion due to the marine environment was a direct cause of the problem. Repair of this machine is nearly complete so that tests on that machine can be completed as scheduled later this fiscal year. Although the structural and fatique problems encountered thus far are considered solvable, we consider this area to be a significant uncertainty since wind turbines have to operate for long periods at high loads. The nearest commercial systems are helicopters and bridge structures, which encounter millions fewer fatigue cycles during a normal life time.

Numerous structural problems have occured on small wind systems. In many cases, these problems were due to the individual manufacturers' specific design and not to a lack of the state-of-the-art.

Unexpected noise problems have been encountered in some of our field test programs, particularly the MOD-1 in Boone, North Carolina. Additional tests are planned this fiscal year, but, based on theorectical analysis and field tests, we feel that noise generated by wind turbines can be reduced to the point that it will not be a significant barrier to the use of wind energy.

The Department has requested $2.2 million in FY 1983 to continue research and technology development on structural dynamics and advanced materials testing with emphasis on fatigue life or rotor blades. No additional funding has been requested to continue noise research, since this research will be completed using FY 1982 funds.

61. Q. The Committee has heard in the past about the need to provide for an accurate assessment of wind enegy resources, particularly at site-specific locations. Does the Department support any funding in this area for either small or large wind machines?

A. As a result of past activities, the Department has published Wind Energy Resource Atlases, covering all regions of the United States. These reports present estimated annual and seasonal average wind power estimates and other information that a prospective wind energy user needs to determine the general nature of wind in the area. Combined with the site evaluation information contained in "A Siting Handbook for Small Wind Energy Conversion Systems" and a similar report for large machines, we feel that individuals and organizations can make decisions regarding the practicability of wind systems for their specific needs.

For the last three years, DOE has supported the installation and operation of metereological towers at 35 utility sites considered as candidates for the installation of large experimental wind turbines. DOE participation in this program is scheduled to be completed in FY 1982. More than half of the participating utilities plan to continue the collection of wind data on their own. The government-furnished equipment will be turned over to the utilities in exchange for an additional year of data at no cost to the government.

The Department is focusing its wind characteristics research in FY 1983 on the effects of variability in wind shear, atmospheric stability and turbulence--all of which affect design loads. Proposed research includes verification of analytical models of induced turbulence due to wind turbine wakes using data from the MOD 2 cluster, investigations of velocity variations to establish the spectrum of rotor loads, and investigation of short-term spatial and temporal correlations of the wind resource.

SOLAR INTERNATIONAL

62.Q. The Department of Energy has requested $9.5 million for solar international activities for FY 1983? For what specific activities will this funding be used?

A. The FY 1983 budget request for SOLERAS will complete funding for all ongoing and planned SOLERAS projects. Projects supported by FY 1983 funds will include the following:

1. Photovoltaic Village Power Project
2. Solar Cooling Field Tests
3. Solar Water Desalination
4. Solar Closed System Agriculture Project
5. Solar Educational Activities
6. and Program Management

63.Q. In accordance with the SOLERAS agreement, the United States and Saudi Arabia have entered into a number of solar activities, includng solar cooling engineering field tests, a photovoltaic village power project, solar energy educational activities, solar water desalination activities, agriculture-related activities and a university solar cooling program. What is the status of these activities at the present time?

A. 1. Solar Cooling Engineering Field Test: During the summer of FY 1981, four solar cooling systems were installed in the Phoenix area and operational tests performed. System modifications and corrections have been completed and a second cooling season of tests will begin in the spring of this year.

2. Photovoltaic Village Power Project: The Photovoltaic Power system began providing power to two small Saudi Arabian villages during the first quarter of FY 1982. Operational testing and operator training are presently being conducted.

3. Solar Energy Educational Activities: A solar storage technology workshop is being held in Saudi Arabia during March 1982.

4. Solar Water Desalination: Extension of Phase I contracts for preliminary design and cost analyses are being negotiated in order to improve system design and decrease construction cost risk. Firm fixed price proposals for Phase II detailed design and construction are expected.

5. Closed System Agriculture Project: Phase I preliminary design and cost analyses are due to be delivered for review during the third quarter of FY 1982. A decision to enter into Phase II detailed design and construction

will be made upon completion of this review.

6. University Solar Cooling Laboratories: Phase I design of solar cooling laboratories has been completed at the University of Petroleum and Minerals and King Saud University. Design work has been extended at King Abdul Agiz and King Faisal Universities. Phase II contracts for fabrication and installation are being negotiated upon completion of Phase I activities.

64.Q. The Department has requested no money for solar information activities for FY 1983. What does the Department plan to do with the Solar Energy Information Data Bank (SEIDB), which has been funded in previous years? How does the Department intend to process information requests in light of this funding action?

A. DOE proposes to phase out the SEIBD in FY 1983. The Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS) will continue to process information requests through the end of FY 1982. The Franklin Institute in Philadelphia, the contractor operating CAREIRS, is currently seeking alternate private funding sources to allow it to continue this service in the future.

Given the availability of solar information in the private sector generally, no further funding effort is warranted. DOE will continue to disseminate the results of R&D programs through the National Technical Information Service and the Technical Information Center as in the past. But general information requests should be channeled to industry and consumer sources already widely distributing such information.

65.Q. Does the Department believe that the private sector will pick up and adequately support conservation and renewable energy information activities?

A. We believe that the various industry and technical trade associations realize the expanded role they need to play in the future and will be able to perform the various functions associated with information and technology transfer during FY 1983. The Department will continue to make available the results of its RD&D activities. The only part of these activities being transferred to the private sector is the packaging of the information reported by the Department in forms desired by ultimate users. We believe the likelihood of this packaging being adequate will be greater when the users have a choice among competing services.

66.Q. The Committee has heard a great deal of testimony about foreign competition in the solar industry. What do you believe would it take to make the U.S. solar industry competitive in the international solar market? What can we do to stimulate increased solar trade overseas?

A. In most solar technologies, the U.S. solar industry is ahead of its foreign competition and can compete very well in the international market. Notably, U.S. firms are acknowledged leaders in photovoltaics, active solar heating and cooling, and solar thermal renewable energy systems, with significant shares of worldwide production. The U.S. solar industry has experienced some past difficulty competing in the international market where trade barriers exist or where other governments underwrite some of the costs of solar systems in order to help their own industries.

On behalf of all domestic industries, the U.S. Government has been participating in worldwide negotiations for a number of years to reduce restrictive trade barriers, and we will continue to carry out such negotiations in the future.

Through the U.S. Trade and Development Program at the Department of State, we have been directly funding various solar feasibility studies for developing countries as a first step in the eventual sale of U.S. solar industrial hardware to those countries. Additionally, the trade fairs sponsored by the Department of Commerce have proven valuable in acquainting foreign customers with the capabilities of U.S. solar manufacturers.

68. Q. The Committee has been concerned about the strong international competition in the solar photovoltaics market. What is your understanding of the impacts of the Japanese competition in the solar photovoltaics market?

A. Although the Japanese government and a growing number of Japanese companies are rapidly increasing their spending and activities in photovoltaic RD&D, the U.S. photovoltaics industry continues to lead in volume of photovoltaic module sales worldwide (with about 80 percent of all sales) and in quality and reliability of modules and systems. Japanese competition is particularly strong in the development and commercialization of amorphous silicon technology, which is being applied largely to power small Japanese consumer products, such as wristwatches and calculators.

The U.S. lead in most areas of photovoltaic technology is still substantial as a result of U.S. government and industry collaboration and commitments over the past 8 years. The FY 1983 U.S. Federal program will focus on selected advanced research areas such as amorphous silicon research.

69. Q. The Committee has heard a great deal of testimony about the merits of the SMUD project. Do you believe that this project is necessary in order to convince the utility sector about the viability of solar photovoltaics systems?

What do you believe could be the appropriate size for a project of this type?

What are your views of the Federal-private risk coverage concept that was presented in the original SMUD proposal to DOE?

How do you plan to go forward with the funds earmarked for the first increment of the SMUD project?

A. The benefits of undertaking a megawatt-scale photovoltaic experimental project have been extensively examined over the past several years. In 1978, the "Southeast Project" study conducted under a DOE contract with Stone and Webster Engineering, Inc., surveyed the technical opinion of key utilities in that region. Their strong recommendation was to undertake a megawatt-scale feasibility project as soon as possible. More recently, the "Industry's Perspective on Federal Photovoltaic Programs" by the Solar Energy Industries Association in July 1981, recommended a megawatt-scale experiment. The Solar Photovoltaic Energy Advisory Committee also recommended such a project. In view of these recommendations and our own analyses, we are convinced that the one-megawatt SMUD project is appropriately sized and will be a significant step in convincing the utility sector of the technical viability of photovoltaic systems.

The Federal-private risk coverage concept that was presented in the original SMUD proposal to DOE involved, in our opinion, excessive Federal participation in private market development activities. The one megawatt experiment is far more appropriate for Government support.

Contract authority for the SMUD project has been assigned to the DOE San Francisco Operations Office, and funds earmarked for the one-megawatt SMUD experiment have been transferred to this office. The office is in detailed discussions with SMUD leading to transfer of these funds under a cooperative agreement that is expected to be signed by this summer.

ADDITIONAL MATERIAL SUBMITTED BY DOE FOR THE RECORD

PROGRAM: SOLAR APPLICATIONS FOR BUILDINGS OCT 15 1981

Administrator: Assistant Secretary of Conservation and Renewable Energy

OVERVIEW

Solar Applications for Buildings covers three primary solar technologies for energy supply to the building sector: Active Heating and Cooling; Passive and Hybrid; and Photovoltaics. Photovoltaic systems supply electric energy for not only the buildings sector, but also for industries and utilities. The program has recently been realigned into the technology areas of Solar Heating and Solar Electric. Photovoltaics is now part of the Solar Electric program. Active Heating and Cooling and Passive and Hybrid have been joined by Solar Thermal to form the Solar Heat Technologies Program.

The legislative framework for the Active and Passive Solar Heating and Cooling Program is based in large measure on four key laws enacted by the 93rd Congress, and the legislation that established the Department of Energy. These are: the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409); the Energy Reorganization Act of 1974 (P.L. 93-438); the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473); the Federal Non-Nuclear Research and Development Act of 1974 (P.L. 93-577); and the Department of Energy Reorganization Act of 1977 (P.L. 95-91). In addition, the National Energy Conservation Policy Act of 1978 (P.L. 95-619) greatly expanded the role of the Active Solar Heating and Cooling Program in promoting solar projects in the Federal sector and for schools, hospitals, and public buildings. In addition the Solar Photovoltaic Research, Development, and Demonstration Act of 1978,(P.L. 95-590) was enacted to establish "an aggressive research, development and demonstration program" for PV systems to produce electricity " cost competitive with utility-generated electricity."

ACTIVE SOLAR HEATING AND COOLING

PROGRAM OBJECTIVES:

Historically, the Active Solar Heating and Cooling Program's goal has been to accelerate the development of a viable active solar industry in order that a 1.5 quad energy contribution from active systems could be achieved by the year 2000. The objectives were to: (1) reduce system costs, improve system performance, and improve system reliability through appropriate research and development efforts and (2) promote and accelerate the commercialization of active solar technologies in the residential and commercial buildings sector through targeted demonstrations and market development activities.

The current program objectives are: (1) to develop low cost/high performance materials and components through advanced research and analysis, and (2) to develop space conditioning systems with significantly improved design, reliability, cost, and performance through systems development activities. Program emphasis is primarily on high risk/high payoff research and development including: research on materials and components; development and testing of advanced components, systems, control methods, and devices; development of high-efficiency collectors; development of high-performance, solar assisted heat pump components; research and development on solar ponds for low temperature thermal applications; and that research necessary to understand the physical and operating properties of materials and fluids potentially utilized in solar energy applications.

The primary alternatives to the Active Solar Heating and Cooling Program are addressed below. While each of the alternatives show some promise, none encompass the range of activities required for carrying out the Active Solar Heating and

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Cooling Program's objectives. For example, Federal tax incentives in the form of tax credits, are primarily increasing the sales volume of water heating systems in the residential sector, with profits generally not going into corporate R&D on space conditioning systems. The enactment of an R&D tax credit may solve this problem, but could also encourage duplication of R&D projects among firms, and increase participation in less promising R&D projects. Utility solar programs are primarily directed at determining how active systems effect their traditional delivery systems and costs, and not on R&D. State/local government solar programs encompass tax incentives as well as promotional work, and to a limited extent developmental activities. However, the majority of states lack the financial base to support the required R&D activities without Federal funding. Finally, industry funded R&D is an unlikely source of the necessary support due to the current weak financial posture of the industry.

PROGRAM IMPACTS:

The Active Solar Heating and Cooling Program has made considerable progress toward achieving its goal of accelerating the establishment of the industry. For example, prior to the implementation of the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409) by DOE, there was virtually no solar industry. By the end of the last Demonstration Program funding cycle in FY 1979, more than 700,000 square feet of solar collectors had been purchased, representing over 270 commercial size projects and 1250 residential units, and involving more than 70 suppliers of solar equipment. For many of these suppliers the DOE Demonstration Program was their prime source of sales during their early development. While the program is not solely responible for the growth of the industry, it has accelerated its development. Similar accomplishments can be shown for the research and development program (e.g., improvements in collector performance and solar cooling equipment), the market development program (e.g., assistance in the development of consensus codes, standards, testing procedures, training methods, and information dissemination), and various other programs under the Active Solar Heating and Cooling Program. Table 1 summarizes program accomplishments by year for each of the preceding four fiscal years.

The Active Solar Heating and Cooling Program has benefited a large number of groups in the public and private sector. The solar industry, particularly the hundreds of manufacturers, distributors, dealers, installers, and professionals (e.g., architects, designers, engineers), directly involved in the various programs, benefited by receiving financial support, and "hands-on" experience, through project involvement. State, and local governments benefited by receiving guidance on how to draft model solar codes, and suggested testing/certification procedures. The general public received information on solar technology and was served by consumer assurance and market standards (e.g., including warranties, etc.), that were developed under the program.

The program has played a major role in the development of the present day active solar industry. This industry now projects annual sales in excess of $300 million in 1981, up from only $17 million in 1975 and $172 million in 1977. From less than 50 solar collector manufacturers in 1975, the industry has grown to more than 300 in the last six years. Total employment of skilled tradesman and professionals is numbered in the thousands. The estimated fuel savings from total installed systems (300,000 - 400,000) is estimated to be between 1.0 - 1.5 MBOE, annually. The overall effect has been to increase employment, increase competition (e.g., spur conventional sources to greater efficiencies), and reduce the cost of energy to consumers in regions of the country where systems are cost effective.

Based on the findings of numerous government studies it can be concluded that the accelerated widespread utilization of the technologies supported by the Active Solar and Cooling Program should have minimal impacts on the nations' health and safety, and may actually help reduce air pollution, by displacing non-renewable fuel sources whose products of combustion are harmful.

In accordance with specific congressional mandates DOE established the following key programs: the Commercial Demonstration Program, the National Solar Data Network Program, the Research and Development Program, and the Solar in Federal Buildings Program. Specific criteria were developed for the kinds of activities and projects funded under these programs and measures of evaluation developed. In particular, emphasis was placed on incorporation of basic conservation/load reducing strategies, cost sharing, and improvements in cost/performance in successive demonstration cycles.

PROJECTED PROGRAM REQUIREMENTS:

Active solar systems have been shown to be technically feasible for a variety of specific applications including hot water, space heating, and cooling. However, the necessary maintainability, durability, reliability, flexibility, and cost effectiveness, particularly for space conditioning systems, does not currently exist. To achieve broader utilization, there must be: (1) significant cost reduction and/or increases in active solar system performance (space conditioning system costs must be reduced by a factor of 2 by 1990 to ensure competitiveness), and (2) significant improvements in system design and knowledge regarding system performance, reliablity, and maintainability (systems capable of operating reliably for 20 years with annual O&M costs of less than 3% of system cost are required).

Given the recent decontrol of energy prices, an enhanced environment for private sector investment and the need for Federal budget reductions, the active solar program is being phased out during FY 1982. The development of a growing active solar industry through Federal and private efforts has provided a fertile environment for continued support by the private sector alone.

DISCONTINUATION REQUIREMENTS:

There are no further legislative requirements for a program phase-out in FY 1982. Administrative requirements present no appreciable difficulties.

PASSIVE AND HYBRID SOLAR

PROGRAM OBJECTIVES:

The historic goal of the passive and hybrid solar program has been to provide an equivalent cumulative contribution of 1.5 billion barrels of oil by the year 2000 through accelerated acceptance and use by industry of passive solar energy measures to heat and cool residential and commercial buildings. Specific objectives toward meeting this overall goal are displayed on table I.

The current goal of the passive and hybrid solar program is to accomplish an orderly phase-out of new Federal program activities during FY 1982. This shift in emphasis is appropriate given recent energy price decontrols, investment tax revisions, Federal budget restrictions and development of the groundwork for continued private sector development.

There are several alternative and complementary means by which the passive and hybrid solar energy objectives could be attained. These include: support for applied research, cost shared development, design aids and assistance, cooperative interagency agreements, demonstrations, education, training and information, incentives and free market decisionmaking based on deregulation. Demonstrations have been successfully completed by DOE and HUD.

Programs within DOE's Office of Conservation are coordinated to avoid duplication of effort. Typically, a national laboratory is established as a focal point for the research (e.g., Argonne for storage, Lawrence Berkeley for daylighting) and each division then relies on those lead researchers. The only other Federal agencies involved in passive solar (e.g., HUD, FmHA) are doing so at DOE's initiative, to leverage the effects of its program. A handful of states, including New York and California, have adopted aggressive passive solar programs drawing heavily on Federal experience. Private enterprise activity is coordinated through the 31-member Passive Solar Industries Council. International activity has, for the past two years, been coordinated through the NATO Committee on the Challenges of Modern Society (CCMS) program and SERI.

PROGRAM IMPACTS:

Between 1978 and 1981, it is estimated that over 500,000 barrels of oil equivalent have been displaced by passive systems. And, it is estimated that passive buildings will displace over 27 million barrels of oil equivalent in 1990 alone as the number of passive buildings grows to over 4 million. This total would not occur until the next century in the absence of a passive program.

Since 1978, several basic heating systems have been replicated and standardized. Methods to predict performance have been developed so that new cost-to-performance indicators can be identified. These basic heating systems are now reliable, and greater control can be exercised over the interior environment. Much of this progress is directly attributable to the Passive Program. Of the 15 heating systems, 17 cooling systems, and 3 domestic hot water systems characterized, development is proceeding on five advanced heating, five cooling, two daylighting and one DHW system in prototypical custom, speculative and manufactured residential and commercial buildings. Approximately 50 different materials and components including IR reflecting films, phase change storage materials and moveable insulation are under development by the program with industry for collection, storage, humidity control, distribution, regulation and rejection of heat energy.

Major program accomplishments include research into the basic natural phenomena of heat transfer and solar radiation, the development of two design handbooks and at least a dozen manuals, adaptation or development of 4 mainframe computer codes and two manual design methods, over 400 prototype building field tests, 24 test cells, 19 instrumented buildings, computer forecasting and market indexing models, a university architectural curriculum, over 250 workshops reaching over 13,000 professionals, direct technical assistance to over 600 builders, media placement reaching audiences as large as 120 million, and home tours for 500,000. In 1977, there were fewer than 500 passive solar residential buildings in the U.S. By 1980, there were 25,000 passive solar residential buildings and about 100 commercial buildings. A recent program overview predicts the number of passive systems in place could be as high as 74,000 new and 111,000 retrofit by the end of 1981. According to a 1981 report, the 1981 passive solar market was between $110 and $150 million annually, leveraged by $89 million total dollars spent by the program in four years. Selected evaluation of representative projects revealed a high return in subsequent private investment.

PROJECTED PROGRAM REQUIREMENTS:

The program is funded at a level of $10.3 million for FY 1982 but will be phased-out thereafter. Although there is still some room for advancement through Federal action in passive solar research and development, the need for budget reductions and the increasing awareness and use of passive solar designs by the private sector warrants the elimination of future budget authority.

DISCONTINUATION REQUIREMENTS:

There are no insurmountable legislative or administrative hurdles to the orderly discontinuation of this program.

10/6/81

PHOTOVOLTAICS PROGRAM

PROGRAM OBJECTIVES

PV sytems have been used to power space vehicles for over twenty years, and are currently being sold for a limited number of very specialized remote terrestrial applications, where no other source of electric power is practical. The historic thrust of the federal program has been to accelerate the development of PV technology that would be technically and economically capable of supplying a substantial portion of U.S. electric power requirements. Some of the problems the program has addressed include: high costs, low efficiencies, and uncertain lifetimes of PV collectors; lack of appropriate power conditioning and other balance-of-system (BOS) components; and the technical, economic, and legal difficulties of integrating PV systems into electric utilities.

The historic goals and objectives of the program were established by the Solar Photovoltaic Research, Development, and Demonstration Act of 1978 (P.L. 95-590). The goal of the Act was to establish "an aggressive research, development and demonstration program" for PV systems to produce electricity "cost competitive with utility-generated electricity." Specific objectives included: doubling the annual production of PV systems every year, culminating with 2000 MWp produced in FY 1988; reducing the average cost of installed systems to $1.25/Wp by FY 1988; and ensuring that at least 90% of PV systems sold in FY 1988 are purchased by private buyers. The Act authorized the expenditure of $1.5 billion over 10 years to achieve these objectives.

The Act required the Secretary of Energy to report to Congress on the feasibility of achieving the Act's objectives or alternative objectives. Meanwhile, the Domestic Policy Review (DPR) of Solar Energy had established the goal of 1.0 Quad/year of primary fuel displacement for PV in the year 2000. The Secretary's report of Feb. 20, 1980, examined seven program options and indicated that the level of funding authorized by the Act was unlikely to ensure the achievement of the FY 1988 production objective, but was consistent with the DPR's year 2000 displacement goal.

The present DOE policy shifts the program thrust further away from production or penetration levels and towards technical feasibility by concentrating on long-term, high-risk, but potentially high-payoff research and development. The overall mandate of P.L. 95-590 will continue to be carried out to the extent feasible within the limits of appropriated funds. The major goals and objectives to be met are listed in Table 2.

Photovoltaic systems produce electrical output only in daylight hours and would primarily displace high-cost peaking and intermediate generation; conventional baseload energy sources would not be displaced until very high penetration levels of PV. Thus, federal programs directed at baseload electricity generation are not direct competitors; while the advanced conventional and other renewable federal energy programs aimed at intermediate and peaking generation address similar objectives.

Government sponsored R&D, including field testing, is rapidly expanding in Europe and Japan in response to the near-term stand-alone remote dc market and the longer-term prospects of distributed ac applications and central

station use. These foreign government programs coupled with significant interest by foreign private firms now in or entering the market are expected to lead to strong competition for near-term markets. Japan's lead in commercialization of low-cost amorphous silicon cells for small calculators to standard rooftop arrays is exemplified by Sanyo's $50 million, four-story plant, the world's largest factory, now nearing completion. By mid-1982, Sanyo expects to be producing a million modules a year of 38 Wp each.

The principal alternatives to the current R&D program strategy are: (1) government purchase of PV systems for use on Federal facilities and power grids to induce technology development, cost reduction and production expansion; (2) financial incentives (e.g. tax credits, grants) to encourage private purchases of PV systems; (3) regulatory programs encouraging or mandating the use of PV systems or inhibiting the use of other energy sources, and (4) a policy of leaving further R&D entirely to private firms.

The first two alternatives ("demand pull" through Government purchases and financial subsidies) both have the deficiency of distorting the market by reducing the competitive incentives for more efficient production and more advanced technology. Also, since the current costs of PV systems are a factor of ten away from being competitive, the level of government purchases or subsidies required to establish a significant market would be of the order of $1 billion. The third alternative (regulatory policy) does not assure the timely development of cost-effective PV technology, but may be complementary to the existing R&D strategy to the extent that barriers to the integration of PV systems into utility grids are reduced; e.g., PURPA has had a constructive impact on the prospects for commercial use of PV technology. The fourth alternative ("do nothing") implies accepting the risk that a PV option may never be available or may be significantly delayed. The last alternative also increases the risk that the U.S. producers may lose their current competitive edge over foreign producers for the domestic as well as the world PV markets.

PROGRAM IMPACTS

A summary of the accomplishments and the annual operating costs of the program for the Fiscal Years 1978 through 1981 are presented in Table 1. Excellent progress has been made both in the actual technical achievements as well as in identifying the remaining critical R&D elements needed to bring this technology to the point of technical feasibility over the next decade for widescale use as a U.S. electric power option.

The Advanced Materials, Cells and Concepts R&D area has achieved 10% conversion efficiency in the laboratory for several potentially low-cost thin-film solar cells. Arrays made from such cells are projected to cost less than $0.45/Wp.

The Collector R&D area has already demonstrated the technical feasibility of $3.08/Wp collectors in 1980, and is well along the path towards the technical feasibility of $0.77/Wp collectors by FY 84/85. Ultimately, the program projects the technical feasibility of less than $0.35/Wp for the new thin-film materials currently undergoing R&D in the Advanced Materials area.

The System and Subsystem R&D area has already developed initial system designs for three levels of utility-connected applications, and has established two operating residential experiment stations for testing of the new prototype PV hardware and systems under simulated residential conditions.

The System Experiments area has initiated a series of first-ever PV experiments to provide feedback to the R&D community on the performance of currently-available hardware and system. Subsequent experiments will involve the new low-cost components to test their ability to perform as planned.

The final area, Limited Market Development, was focused in the Federal Photovoltaics Utilization Program (FPUP), authorized by Congress as a three-year, $68 million program. Although only $24 million was actually appropriated in this period, a total of 2772 applications (ranging from a few watts to 25kWp) were installed by 26 participating federal organizations in four cycles of procurement. The principal accomplishments were to increase federal agencies' awareness of PV applications and the contractors' ability to supply PV systems.

In general, the Photovoltaics Program has stimulated major private sector participation in R&D and venture capital commitments which, in turn has poised several firms for future entry into or expansion of present commercial commitments. There are 300 active PV organizations in the United States and about 385 worldwide according to recent surveys. The three largest module manufacturers account for about three-fifths of shipments. The 1980 module shipments are estimated to be nearly 4MWp, with revenues of $40 to 50 million, up a factor of two over the previous year. The dramatic increase of private investment, estimated to be a total of $100 million in 1980, is in proprietary research, manufacturing and marketing. Much of this is part of industry's long-term multi-stage investment plan, and is predicated on an agressive federal PV R&D presence and growing market prospects worldwide.

This, combined with the R&D accomplishments, suggest that PV is presently "on-track" to becoming a viable source of electrical power in the United States and the world. The direct beneficiaries of the PV program are: (1) private firms involved in the manufacture, assembly, installation, sale, and service of PV systems; (2) the electric utilities seeking long-term power options; and (3) the general public that would have a new renewable energy option competitive with alternate fossil energy systems. Other beneficiaries would include industries aided by scientific and technological spinoffs from the PV R&D program. For example, reductions in the cost of producing silicon wafers, achieved by the program will provide up to one billion dollars in benefit to the electronics and computer industries and their customers.

The major impact of both the past and present program on the national economy will occur beyond 1990.

The key economic benefits of the program will be the electric utility's avoided energy costs resulting from the accelerated deployment of PV systems. There are four major types of such benefits: (1) displacement of conventional fuel; (2) displacement of generating capacity; (3) transmission and distribution credits; and (4) operations and maintenance credits. Based on a "reference case" which assumes industry domestic sales to grid-connected

consumers reaches 200 MWp/year in 1991 and 50,000 MWp cumulative installations by 2003 (with annual sales following a "logistic curve"), the program has estimated the present value of the program's economic benefits (including national security and environmental benefits) at about $11 billion ($1981) and a five year acceleration due to the program. This assumes an annual rate of escalation in the real price of oil of 3%. Even with 1.5% real oil price escalation, the program would confer nearly $7 billion in benefits, and at a higher oil price escalation rate of 4.5%, the value of the program benefits would rise to $17 billion.

Photovoltaic systems appear to offer substantial environmental benefits relative to conventional sources of electrical power that PV can displace. PV systems can be silent, passively cooled, are modular and have no moving parts. They emit no effluents, and their manufacture does not produce harmful emissions or waste products. The dominant PV material, silicon, is abundant and chemically inert. The production of PV systems does not depend on the availability of strategically vulnerable materials. Their energy source is secure and inexhaustible.

Considerable attention has been focused, through DOE-funded detailed examinations, on worker health and safety in PV collector manufacturing facilities. Manufacture of some advanced PV cells could expose workers and neighbors of plants to toxic substances; however adequate substance control technologies either exist or can be developed to mitigate any hazard. The PV program is actively promoting the development of adequate control technology to insure worker safety from toxic exposure. PV land impacts are no greater than those of other energy sources that PV would replace (particularly when the added land areas involved in mining or drilling phases are considered), and probably will be less because of PV's modularity, lack of on-site effluents, and adaptability to existing constructed areas such as rooftops. On the other hand, the air quality impact of PV should be extremely positive compared to the combustion of fossil fuels which PV generally would displace.

The overall incremental benefit/cost ratio for continuation of the PV program has been calculated to be 56:1, assuming 50 GWp of systems installed by 2003 and a five year acceleration. More pessimistic estimates of future installations reduce the expected benefits; the benefit/cost ratio would be 11:1, if only 10 GWp were installed by 2003 (ignoring subsequent installations).

PROJECTED PROGRAM REQUIREMENTS

Even though the larger PV industry participants have already made sizeable investments, rapid development of PV still involves substantial technical and economic risks. Economic viability of photovoltaic systems in utility-connected applications still require a factor of 10 reduction of costs. For such applications serious uncertainties remain regarding utility interface requirements, system design and performance, safety, reliability, lifetime and maintenance. Furthermore, it is uncertain which technical approaches and products will succeed. This greatly increases the normal risk of product failure and obsolescence of production facilities. Because of these formidable costs, risks and uncertainties, it is likely that the industry will focus its attention on the much simpler stand-alone remote dc markets. But, even here the current U.S. domination is already being

challenged by French, German, Japanese and Italian firms that are strongly supported by their governments. U.S. industry future investments in component and product development for domestic utility-connected markets are sensitive to the risks, cost and uncertainties just described. The necessary generic system tests and evaluations are costly and are likely to benefit competitors as much as the pioneering firm; therefore, industry is unlikely to perform these tests. A further factor is that it is presently uncertain as to whether the cost targets can be met at all.

The Photovoltaic Program will support only the critical component research and development and initial prototype system tests which can lead to the technical feasibility of cost-effective utility-connected systems; the remaining risks and cost to industry to establish the commercial readiness of PV systems are anticipated then to be low enough for firms to invest in their own product development, testing and marketing. The program generated information should: assist private firms in making efficient investment decisions; facilitate contribution of ideas by smaller firms; encourage technical diversity and competition; and lead to early commercially available, cost-effective systems. This planned DOE/industry cooperative R&D program to establish the technical feasibility of PV systems is expected to accelerate the commercial readiness of PV systems by approximately 5 years compared to leaving the development entirely to the private sector. The program objectives and budget requirements are summarized in Table 2.

The current Photovoltaic Program efforts are expected to lead to the PV system technical feasibility goals shown in Table 2. The outyear funding (FY 1983-1987) required to achieve these goals is $260 million. If the outyear funding is increased to $360 million these goals would be accelerated by approximately 1 1/2 years, and with an outyear funding increased to $625 million, the acceleration would be about 4 years.

Funding variations of +10% or -10% might produce change of 7 months (acceleration) and 1 year (delay) with the resultant benefit changes of +1.5 and -2.5 billion dollars respectively from the level of $11 billion ($1981). Reduced funding would stretch out accomplishments of Technical Feasibility more than the corresponding funding increases would accelerate them. This is because there are significant fixed commitments to monitor and evaluate existing experiments, and because more contract efforts would be carried out sequentially rather than concurrently.

DISCONTINUATION REQUIREMENTS

Undue disruption because of program discontinuation could be ameliorated by a gradual phase-out of selected program elements, especially in cases where projects are nearing completion. PV R&D at DOE, NASA, and SERI Laboratories could be phased out over a two-year period and most contracts with industry could be terminated in FY 1983, at an estimated cost of about $30 million. Authorizing legislation (Photovoltaic RD&D Act of 1978: PL 95-590) may need to be amended.

Table I

ACTIVE SOLAR HEATING AND COOLING Program
PROGRAM ACCOMPLISHMENTS
CURRENT DATA ($ MILLIONS) STATUS

Other Programs (Institutional)	FY 78	FY 79	FY 80	FY81	Degree Original Objective Met
	$17.7	$20.5	$23.1	$17.5	

Goal: Assist in the development of viable solar industry to reduce national dependence on non-renewable forms of energy

Obj.

1. Reduce costs, improve performance, and improve system reliability

- Components/materials RDD
  - Advanced CPC collectors developed
  - Demonstrated horizontal feasibility of salt gradient pond for annual storage
  - Developed controller that could reduce backup fuel requirements by 10%
  - Completed development of several new collector types
  - Compiled and published handbook for designers and builders of thermal storage systems
  - Fabricated and tested evacuated tube collectors
  - Initiated construction of large research pond for studies of gradient control & heat extraction
  - Continued development of low cost plastic collectors
  - Analyzed Freons for use in cooling systems
  - Developed and tested collector designs and space conditioning systems with potential for improved performance and reduced cost. Initiated preprototypal concept to aid in improving system reliability.
- Systems RDD
  - Initiated development of advanced solar assisted heat pumps
  - Developed and tested a modular 3-ton cooling system capable of providing 65% of rec. cooling load
  - Developed computer codes for modeling various storage systems
  - Demonstrated perf. potential of SAHP in 40°-100°F range
  - Installed several solar/Rankine cooling systems in operational test sites
  - Developed 3 heat pumps for solar systems and special test facilities for performance monitoring
  - Developed several 1ad generation absorption chillers COPs of .75 with medium temp. input
  - Advanced hot water performance prediction computer program developed
  - Established eng. data base for collector performance prediction
  - Developed residential heat pump systems
  - Demonstrated feasibility of commercial steam absorption systems
  - Initiated pre-packaged heating system solicitation
  - Established practical performance levels for current Rankine and absorption chiller systems in res. and comm. applications

2. Promote and accelerate the commercialization of active solar technologies in the solar & commercial buildings sector

Demonstrated combined feasibility of active solar technologies & provided info. to industry & gen. public on system capabilities. Identified need for further cost reduction & system reliability improvements to accelerate commercialization

- Demonstrations and field testing RDD but mainly Institutional
  - Funded 83 space heating and cooling projects under Pub 571 of commercial demonstration program
  - Continued design and construction of an additional 130 projects funded under PON I, PON II and the Retrofit/Manufactured Institutions
  - Established National Solar Data Network (NSDN)
  - Continued design and construction of demonstration projects
  - Increased number of instrumented sites to 75 under the NSDN
  - Continued design and construction of demonstration projects (170 fully operational)
  - Began selective refurbishment of early projects
  - Included non-Federal projects in NSDN
- Market Development
  - Initiated Solar in Federal Buildings Program (SFBP)
  - Established promotional training and education activities
  - Conducted design workshops for Federal Agency personnel under SFBP
  - Published SFBP program rules and selected 843 projects for funding
  - Initiated Suitability and Econ Extendibility Program (SAE)
  - Began design & construction of SFBP projects (400 completed by end of fiscal year)
  - Published SAH hot water system design guidelines
  - Established SAH solar data bank
- Development consensus collector test standards that were adopted by industry
- Initiated work with industry on model code document
- Developed interim performance criteria for solar systems
- Prepared draft model code document
- Initiated publication of solar law reporter
- Initiated development of hot water system test procedures
- Initiated program for national voluntary including certification testing
- Initiated code official train-
- Established comprehensive market/industry data base
- Completed code official pilot program/interim model code document

PASSIVE/HYBRID DIVISION
PROGRAM ACCOMPLISHMENTS

ACTIVITY	OTHER PROGRAMS (similar or duplicative)	FY 78	BUDGET STATUS ($millions) FY 79	FY 80	FY 81	MAJOR OBSTACLES, OBJECTIVE MET
		Planned 7.0	23.6	34.4	35.3	
		Actual 7.0	23.0	34.4	30.2	
1. Conduct R&D to identify cost & performance, develop an understanding of physical phenomena, & document systems, materials & components for passive heating & cooling. Successful completion will result in increased understanding of systems, components, assemblies, & phenomena.	Conservation; Buildings & Community Systems	• 12 heating test rooms constructed & direct gain & mass wall studied • 2 Skytherm test buildings complete	• Test room assessment of sol. surf. Y. wall & convective loop studied • 15 buildings monitored • 17 cooling systems characterized	• Construct 2 heating test facilities • Design 1 cooling test facility & begin research • Study interzone heat transfer	• Construct 2 cooling test facilities • Set system & component cost/performance goals • Perform simplicity studies & thermal comfort simulations	• Cost/performance goals established • Good understanding of simple zone heat transfer & operation of 2 heating systems
2. Develop analytical methods for rigorous technical & economic assessment of passive solar homes. Successful completion will result in improved ability to predict performance.	(none)	• 5 PASOLE simulation models developed • Design analysis for 29 climates	• PASOLE validated for direct gain sunspaces, & storage roof • Passive incorp. in DOE-1, BLAST, SOLAR	• Develop DEROB, SUNCAT • Refine computer algorithms • LANL analysis complete	• Add cooling algorithms • Validate DOE 2.1, BLAST 3, DEROB & SUNCAT • Develop BLAST 4 • PSPA model complete	• Reliable computer codes & models developed & validated plus passive added to existing heating & cooling load models
3. Develop a range of passive hybrid components & products which can be easily integrated into conventional practice. Successful completion will result in increased availability of materials, components & assemblies & industry investment.	(none)	• Developmental work on thermic diode, PCM, heat mirror, heat pipes	• Initial product development for glazings, water roof storage, controls, reflectors, insulators	• Field test 8 products • Initiate development of 22 innovative materials & components	• First components begin production runs • Initiate developing of cooling components • Concept development for subsystems	• 13 component projects reach stage for private sector commercialization • IR reflective films, movable insulation, PCM storage all in market production. Initial improvement in performance as high as 30% • Leverage of government/private investment 6:1
4. Develop marketable designs for new & retrofit residential & commercial buildings. Successful completion will result in increased availability of system designs & industry application.	R&D Passive Initiative		• Initiate prototype development with 27 manuf. building companies • Initiate house plan development	• Develop 33 prototype commercial building designs • Generate 6 MF building designs • PASOLE completes Solar '80' designs	• Completed 30 commercial building designs • Complete 13 manufactured building prototypes • Develop 40 prototype house plans in 4 regions • Other DOE/CS implement residential design pro-	• Over 200 residential designs available-33 commercial buildings prototype developed; Prototype designs available to manufacture housing industry, representing 35% of new home construction • Over 800 house plans distributed

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PASSIVE [illegible] ED DIVISION
PROGRAM ACCOMPLISHMENTS

GOALS/FUNCTIONS	OTHER PROGRAMS (similar or duplicative)	FY 78	FY 79	FY 80	FY 81	ULTIMATE PROGRAM OBJECTIVE (2000)
		BUDGET STATUS ($millions)				
5. Field test passive heating & cooling systems in new & retrofit residential & commercial buildings. Successful completion will result in the construction & evaluation of prototype buildings.	(None)	• Initiate passive home awards with HUD • Publish data on 5 experimental buildings	• Begin HUD cycle 3 new & retrofit • Publish data on 15 experimental buildings	• Complete HUD demo programs • Design & purchase low cost data acquisition system • Test facility construction started	• Install 30 dataloggers • Publish results of 300 homes in demo program • Postoccupancy audits on 400 homes • Greenhaven house finished • Denver Metro builders assistance complete	• Over 300 buildings field tested • Data for 4 years of experimental buildings collected & disseminated • Over 400 buildings investigated • Test facilities at NBS, U of Arizona, Trinity U complete & 3 systems tested. • Results on 24 test cells & 19 instrumented buildings complete for simple heating.
6. Develop & disseminate design tools for architects, builders, designers. Successful completion will result in availability & application of design methods appropriate to users	Navy, NSF	• Begin development of ELA	• Begin development of DOE-2/PAF	• Publish ELA handbook, Vol. I & II • Publish DOE-2/PAF	• Pass design tools committee • Develop 2.0 version of F/Chart - ELA LOAD, Vol. III complete	• Residential design tool for heating mostly done - commercial 50% complete • Design methods for heating systems available for all levels of application from graphic, manual, & microprocessor to mainframe computer • 2 design handbooks published • 4 construction notebooks
7. Displace 50,000 barrels per day of oil equivalent (.004 quadrillion Btu and of FY81 in the form of .2 million residential installations, 4300 million-ft² of commercial buildings, & $1 billion in annual sales.	Active Solar, Photovoltaics, Biomass, Wind energy	900 residential	• 10,000 residential	• 25,000 residential	40,000 residential	• 2,000,000 ft² of commercial space was built; 40,000 homes can be accounted for; the industry volume is worth $100-150 million

TABLE 1: PHOTOVOLTAIC ENERGY TECHNOLOGY PROGRAM ACCOMPLISHMENTS
(Goals in FY 1981 Dollars)

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	FY 1978 $0.0	FY 1979 $20.2	FY 1980 $59.4	FY 1981* $33.2	MAJOR TECHNICAL OBJECTIVES MET
ADVANCED MATERIALS, CELLS, AND CONCEPTS R&D						
To work closely with University and Industry organizations to continue research and development on novel PV materials and devices, within a comprehensive R&D base program, to develop the maximum efficiency potential and/or lowest cost potential of PV collectors or systems	Japan's[a] Project Sunshine Various[a] European Economic Community Programs	Programs initiated in Emerging Materials, Thin film Polycrystalline Silicon, Basic Mechanisms and Amorphous Materials On going work in cadmium sulfide type cells	SERI Lead Center assumes management Innovative concepts program started Advanced Concentrator and Photoelectrochemical programs started	First 10% lab cell 17% thin-film gallium arsenide cell 16% multi-junction cell Exploratory development started on thin-film polycrystalline silicon devices	Three thin-film achieve 10% lab cell 10% cadmium zinc sulfide/copper indium diselenide cell with stability without encapsulation 6% amorphous silicon cell with 1 cm^2 area	Several thin-film cells are attractive candidates for meeting lab PV goals. Three announced by '85/'86/'88. 30% multi-junction concentrator cell likely by FY 1984
PHOTOVOLTAIC COLLECTOR R&D						
To develop the materials, devices, structures, encapsulation, etc. of PV collectors (both flat-plate and concentrating) needed to establish the technical feasibility (TF) for industry scale-up, as follows: **Collector (1980) Price Target** / **TF At** $5.00/Wp — 1980 $0.77/Wp — 1982 $0.17-0.44/Wp — 1986	Japan's[a] Project Sunshine Germany's[a] polycrystalline silicon program	Several silicon refinement processes identified with $15/kg cost potential 5 silicon ribbons simultaneously, 11% efficiency Row qualification specs for modules issued based on results of Block 1 & 2 procurements and testing Semi-continuous silicon ingot growth achieved 95% Fresnel lenses achieved 25% efficiency beam splitter device	JPL Lead Center for Technology Development and Applications assigned management role for balance of PV Program Union Carbide Complete design of low-cost silicon refinement process Multi-Silicon concentrator arrays by Martin-Marietta and Spectrolab enter testing Advanced silicon concentrator cells achieve 19% efficiency at high concentration	Flat-plate TF at $5.00/Wp demonstrated Block 3 modules delivered (217kWp) for test Ingot growth with sequential replenishment Three concentrator designs meet $5.00/Wp TF Planar Junction silicon cells achieve 20% efficiency at 30-70 suns	Automatic assembly of solar cell strings Encapsulation materials and processes show promise of meeting $15/m^2 goal with over 20 year life Two contracts awarded for automated cell and module processes System experiments using 700 kWp total of concentrating collectors starting field tests Fresnel lens design optimization and analysis tools developed Several collector approaches may be able to exceed $0.77/Wp goal	TF at $5.00/Wp fully met for flat-plates and concentrators Good progress toward $0.77/Wp collectors; slipped 2 to 3 years to FY '84/85 due to funding reductions

[a]Non-DOE Funded

TABLE 1: PHOTOVOLTAIC ENERGY TECHNOLOGY PROGRAM ACCOMPLISHMENTS (Continued)

GOALS/OBJECTIVES	OTHER PROGRAMS (Supplementive)	FY 1978	FY 1979	FY 1980	FY 1981	MAJOR CRITICAL OBJECTIVES MET
STATION & UNDERSEA MAP						
To develop the balance-of-system (BOS) components (i.e., power conditioning, structures, storage, etc.) needed to couple with PV collectors to establish the technical feasibility of systems cost-competitive with utility electricity as shown:	EPRI*	Large system conceptual design	First flat-plate ground-mounted structure designs Residential preferred designs started	Installation cost study for small and medium systems started Wind effects tests on structures completed Two small power conditioning systems (PC) commercially available for test First medium size detailed designs Utility-interface issues preliminary analysis Interim performance criteria document	Two BOS operational, 13 prototypes under test Modularity study for arrays complete Subsystem design and optimization study completed Residential PC implementation plan completed 62.5 kW PC delivered for test Six Residential preferred designs published PRDA 35/38 designs documented Utility Dynamic interaction study started: interface issues report published	Small PC performance deficient. Large PC performance and cost will be met. Promising BOS requires further work, but is on track BOS testing slipped about 6 months Designs on schedule with retrofit and detailed large system designs underway Utility interaction issues largely unresolved
Installed System Price $5.60-14.30/kp (by 1980, for Remote Stand-Alone ac) $1.75-2.40/kp (by 1982, for Residential ac) $1.35-2.05/kp (by 1986, for Utility & Retrofit residential ac)						
SYSTEMS EXPERIMENTS						
To work closely with industry by (cost-sharing industrial automation and system experiments and demonstrations) to assure the actual market availability of the collector at installed system prices — 2 years after TF for de stand-alone remote systems and 4 years after TF for the residential and utility systems	Japan's Project Sunshine* EEC PV Program* Italian "Dolphus" 1 MWp project on ENEL grid*	19 remote stand-alone experiments on-going PRDA 35/38 projects started (medium size systems) Two college grant projects started in Arkansas and Mississippi (medium size)	PRDA 35/38 designs completed Natural Bridges 100 kWp project construction started SOLERAS Project* 500 kWp concentrator system initiated.	Residential emphasis First-of-kind residence in Florida, Arizona Georgetown grant project started Italian "Delphus Project" started* Private PV 75 kW project started for EPCOT Center based on PRDA designs*	First lived-in residential experiments (4) operational Large system experiment proposed Phase-out of remote stand-alone started California Energy Commission sponsored PV residence started* EEC medium size system experiments (19) started* First PRDA 35/38 projects operational	Remote stand-alone objectives met. Test results used to identify R&D requirements, particularly for modules Grid-connected experiment initiated and are on-track with scope limited by budget

TABLE 1: PHOTOVOLTAIC ENERGY TECHNOLOGY PROGRAM ACCOMPLISHMENTS (Continued)

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	FY 1978	FY 1979	FY 1980	FY 1981	DEGREE ORIGINAL OBJECTIVES MET
LIMITED MARKET DEVELOPMENT						
Accelerate and facilitate private sector efforts to develop and meet demand for PV systems Federal Photovoltaic Utilization Program (FPUP) to encourage Federal agency use of PV Assist industry in defining markets Develop limited "market pull" options for domestic and international markets	None	National Energy Conservation Policy Act of 1978; Sect. 953 established FPUP	Initiate market development activity Start FPUP PV Research, Development and Demonstration Act (PL 95-590)	"Federal Policies to Promote Widespread Utilization of Photovoltaic Systems" Report sent to Congress "International Photovoltaic Plan" Report sent to Congress	Complete FPUP procurements (2772 applications, $24 million)	FPUP funded at 25% of authorized level. Twenty-six Federal organizations participated in the four cycles of procurement. Remote stand-alone products developed by contractors are finding wider commercial markets. Federal agencies use of PV increasing.

[illegible] Funded
*50/50 U.S./Saudi Arabia Funding

TABLE 2: PHOTOVOLTAICS CURRENT PROGRAM OBJECTIVES AND BUDGET

(Budget data in FY 1982 dollars, millions)

(Goals in FY 1981 dollars)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED IMPACT	BUDGET JUSTIFICATION AND SERVICES PROVIDED
• To work closely with university and industry organizations to continue research and development on novel PV materials and devices, within a comprehensive R&D Base Program, to develop the maximum efficiency potential and/or lowest cost potential of PV Collectors & Systems. • To develop the materials, devices, structures, encapsulation, etc. of PV collectors (both flat-plate and concentrating) needed to establish the technical feasibility (TF) for industry scale-up • To develop the Balance-of-System components (i.e., power conditioning, structures, storage, etc.) needed to couple with the above collectors to establish the technical feasibility of PV systems cost-competitive with utility electricity as shown: Collectors - $0.77/Hp Installed Systems $1.75-$2.95/Hp TF Date 1985/1990, AC residential and intermediate size applications Collectors - less than $0.35/Hp Installed Systems $1.25-$2.00/Hp TF Date 1985/1990, DC utility and retrofits for residential and intermediate size applications	• Government purchases • Tax credits to system purchases • Leave further R&D entirely to private firms • Regulatory policies	• Meeting 1984/85 objectives creates opportunity for significant U.S. utility-connected market • Meeting 1988/89 objectives greatly broadens U.S. market potential and builds from base of previous accomplishments • Continued pace of program needed to meet foreign competition and maintain efficient contractor teams	Proposed BA FY 1982: $2.9 million Outyear expenditures FY 1983-1987 - 240 million • Large cost reductions needed to make PV an attractive generating option to utilities require R&D now rather than tax credits. • Private industry is unlikely to pursue parallel development of existing stand-alone and utility-connected applications. • Program should accelerate commercial availability of significant PV energy supply by approximately 5 years. • Program conducts critical high-risk R&D to obtain needed large cost reduction for collectors and BOS; Generates technical information about utility interconnection and generic systems design through system testing thereby reducing the unacceptable risk to subsequent private development and marketing of products for utility-connected market.

All price targets in 1981 dollars without subsidy of solar tax credits

96-882 O—82——46

PROGRAM: SOLAR APPLICATIONS FOR INDUSTRY

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

OCT 7 1981

OVERVIEW:

The Solar Applications for Industry Program is composed of Biomass Energy Systems (BES) and Solar Thermal Energy Systems (STES). Together, they represent a comprehensive approach to energy supply enhancement serving a wide range of end-use sectors. BES is developing technologies to produce liquid and gaseous fuel and chemicals as direct substitutes for petroleum products; STES is developing technologies for conversion of solar energy to electricity or to thermal energy for direct use or storage.

BIOMASS ENERGY SYSTEMS

PROGRAM OBJECTIVES:

The Biomass Energy Systems (BES) Program has supported biomass feedstock and conversion technology development to provide economically competitive fuels and chemicals from biomass to reduce U.S. dependence on petroleum and natural gas. The Energy Reorganization Act of 1974 authorized "research and development programs respecting all energy sources," specifically referring to solar and renewable energy. This legislative mandate was extended by the Solar Energy Research, Development, and Demonstration Act of 1974 and the Federal Nonnuclear Energy Research and Development Act of 1974. The DOE Organization Act of 1977 transferred responsibility to DOE and the DOE National Energy Conservation Policy Act of 1978 established further provisions to encourage R&D "to produce alternative fuels from . . . biomass . . . " The Energy Security Act, P.L. 96-294, mandated a program "for increased production and use of biomass energy" to "reduce dependence of the United States on imported petroleum and natural gas."

BES addresses two interdependent problems: production of a supply of appropriate biomass feedstocks in sufficient quantity to make conversion economically feasible without disruption of food and fiber markets, and development of technologies to convert this biomass to liquid and gaseous fuels and chemical feedstocks at competitive costs and in sufficient quantities. Original objectives, as developed by the Fuels from Biomass Activity, are shown in Table 1. The earlier biomass programs emphasized development of near-term wood applications and on-farm systems. The BES program has changed emphasis and organizational structure. The present program focus is on long-term R&D projects to address the continuing demand for both adequate feedstock supply from a wider range of sources and also conversion technology capable of satisfying output and cost objectives. This changed focus in reflected in the current objectives listed in Table 2.

BES activities complement other CE/DOE program efforts to reduce demand for and increase supply of energy. For example, BES and the Office of Alcohol Fuels (formerly a part of BES) share development of biochemical technology although they are investigating different outputs and end-use sectors. The Basic Energy Science program conducts research that complements part of BES exploratory research projects. DOE's Office of Industrial Programs conducts an Energy Integrated Farm subprogram that includes biomass and other technologies in an on-farm system; and USDA manages herbaceous and silviculture subprograms in cooperation with BES. Coordination of R&D efforts and avoidance of duplication are considered major BES program management responsibilities.

Possible alternative methods for achieving BES objectives could include greater reliance on the private sector, changes in programmatic emphasis, removal of energy-related subsidies, and changes in Federal tax policy. Removal of energy-related subsidies and rising energy prices will increase incentives for private sector R&D, but will not be sufficient to achieve the socially optimal level of long-term R&D investment. Therefore, reliance on the private sector alone is not an adequate alternative. The private sector will underinvest in long-term exploratory R&D as long as one or more of these conditions holds: (1) social benefits exceed private benefits; (2) the social discount rate is less than the private discount rate due to distortions induced by tax policies and/or other factors; (3) private benefits are not fully appropriable, for example, when R&D results in a generic process which is not patentable; and (4) a firm funding a single project faces greater relative risk than does the government when it sponsors a portfolio of projects.

PROGRAM IMPACTS: Programmatic emphasis has been changed, eliminating near-term activities likely to be undertaken by the private sector and emphasizing long-term, high-risk R&D. A major goal of BES is to accelerate private sector progress in biomass feedstock and conversion technology by more rapid expansion of the fundamental technology base.

Program accomplishments by year, indicating steady progress toward objectives, are shown in Table 1. As examples of this progress: the Bartow anaerobic digester facility for biochemical conversion of manure to biogas, after initial demonstration, has been transferred to the private sector. The thermochemical conversion program has shown the technical feasibility of converting biomass into synthesis gas for lower cost, more direct production of hydrocarbons including liquid fuels. Also proof-of-concept has been demonstrated in the fast pyrolysis of biomass into high value fuels. BES R&D on short-rotation woody crops has demonstrated yields up to 12 dry tons per acre per year from species such as hybrid poplars. The photobiological hydrogen program has identified the location of the hydrogen-producing gene on the chromosome of E.coli; this will permit genetic manipulation for hydrogen production. Production of biomass energy from conventional wood resources and near-term applications have been transferred to the private sector.

Impact of the BES program differs among program elements. Estimates indicate that BES R&D, compared to private sector activity alone, will advance biomass energy resource/technology availability from 10 years for herbaceous feedstocks and some thermochemical conversion technologies to up to 25 years or more for aquatic feedstocks and photobiological conversion.

Benefits to the economy from the BES program will be significant; since many projects involve long-term R&D, near-term impacts are small relative to potential. Production of energy from biomass is more labor-intensive than from conventional sources; therefore, increased employment per quad of energy can be expected. Competition should be increased due to the dispersed nature and reduced capital-intensiveness of biomass production and conversion.

Other benefits from the BES program are be more regional or sectoral. Due to the economics of biomass harvesting and conversion processes, benefits tend to be concentrated in the regions in which the feedstocks are available. Economic rents will accrue to private owners of land and other resources necessary to increase feedstock production. Much of the marginal and arid land to be utilized by the BES herbaceous and short-rotation woody species under development is Federal land which is now unused or underutilized. Farms and small communities may find biomass a means to achieve energy self-sufficiency, with resultant security and cost savings. Industry will benefit from enhanced supply of liquid and gaseous fuels. Industries now requiring petroleum-based feedstocks will benefit from successful projects that lead to increased supply of petroleum substitutes.

Most of the health and safety impacts resulting from the BES program are small and/or beneficial. Increased use of wood resources may lead to an increase in job-related accidents unless more effective safety measures are developed. Environmental, safety, and health impacts generally can be more favorable for production and use of biomass energy than for energy from conventional sources. For example, increased production and utilization of biomass as fuel, since biological growth uses CO_2 produced by fuel consumption, will ameliorate the problems of increasing CO_2 concentration in the earth's atmosphere. Fossil fuel usage contributes to increased CO_2 concentration without such compensating reductions. Careful analysis of health and safety impacts and the necessary measures to avoid or ameliorate negative impacts are considered an inherent responsibility of the program.

PROJECTED PROGRAM REQUIREMENTS:

BES program funding of $12.2 million is requested for FY 1983. This reduced funding level reflects the current objectives of BES. If this funding level (in 1981 dollars) is continued through the 1980's, it should provide the technical basis for increased supply of biomass fuels and feedstocks and for more energy-efficient and cost-effective conversion technology.

Federal intervention in support of the BES program is justified both in terms of expectations that the private sector will underinvest in this type of R&D and also in terms of the value of the benefits to be derived specifically from the BES program. Part of the unique value of the BES program inheres in the provision of liquid and gaseous fuels and feedstocks that will be direct substitutes for petroleum products and natural gas without requiring elaborate storage technology.

The relation between funding level and services provided by BES is not a continuous function. An increase in the level of funding by 10% accelerates progress in conversion technology by broadening the program and is expected to result in an additional .1 Q/yr. in 1985 and .7 Q/yr. in 2000. More technologies, and a wider range of variables, can be investigated and advanced from lab-scale through intermediate scales (e.g, PDU) to subcommercial scale. Accumulation of sufficient data on operating parameters is essential to establish the commercial feasibility of an innovative technology. Since the program is currently operating on a minimum-level budget, any decreased funding would mean major deletions in projects and resulting delays of 5 years or more in achieving objectives for that conversion technology. A 10% cut in funding for the BES program would eliminate at least two gasification projects and reduce the probability of achieving biomass conversion cost goals.

Biomass feedstock development (herbaceous, woody, and aquatic) represents the other side of the BES development program. If funding is increased, more species can be included in the characterization projects and each investigated more thoroughly thereby broadening the resource base from which the most promising sources of energy biomass can be selected. This increases the probability of finding species with the highest yields and with yields having desirable characteristics (e.g., higher percentage hydrocarbon content in the cell mass produced). Budget cuts will severely limit the number of species to be investigated and the breadth of data to be collected.

DISCONTINUATION REQUIREMENTS:

The requirements for discontinuation of the program elements vary due to differences in the nature of the R&D projects involved and project combinations within program elements at time of termination. To discontinue the entire BES program would require at least one year and possible three years depending on timing and on the nature of projects in progress at the time. The process of orderly termination would require approximately $13.6 million - $18 million for contract close-outs and personnel termination. There would be sunk costs of $25 million to $35 million invested in capital equipment for projects that would not be completed.

SOLAR THERMAL ENERGY SYSTEMS

PROGRAM OBJECTIVES:

Solar Thermal Energy Systems (STES) produce heat from solar radiation which can be used in applications spanning the U.S. energy spectrum: utilities, industrial processes, and the production of fuels and chemicals. The Federal program conducts R&D for concentrating collectors (i.e., central receiver, parabolic trough, parabolic dish, and hemispherical bowl) and large-scale salt gradient solar ponds.

Predicated on a need to achieve energy independence and maintain technological preeminence, a Federal decision to conduct STES R&D began with a Presidential Commission's recommendation in 1952, proceeded through several NSF, NASA and AEC panel recommendations, and in 1974 was mandated by public law. Once solar thermal cost of energy delivered is lowered, technical reliability is achieved, and the technology is employed on a mass scale, important public benefits will accrue due to reduced energy price escalations.

The Solar Energy Rsearch, Development and Demonstration Act of 1974* (P.L. 93-473, Sec. 2(b)(1-2)) set policy to "pursue a vigorous and viable program of research and resource assessment of solar energy as a major source of energy for our national needs; and provide for the development and demonstration of practicable means to employ solar energy on a commercial scale." The Act created functional objectives (Sec. 7(a)(1-6)) to demonstrate technical and economic feasibility of STES (Sec. 6(c)(1&2)):

(1) production of electricity from a number of 1-10 MW power plants;

(2) production of synthetic fuels in commercial quantities;

(3) large-scale utilization of solar energy in the form of direct heat;

(4) utilization of thermal and all other solar facility by-products;

(5) design and development of hybrid systems involving the concomitant utilization of solar and other energy sources; and

(6) continuous operation of such plants/facilities for a time period.

The Energy Research Act of 1977 (P.L. 93-39, Sec. 102(d)) added a seventh functional objective: a 5 MW demonstration for small community applications. Because cost was a key barrier to the Congressional intent of commercial scale development and demonstration, three cost-performance objectives were developed. Technical feasibility dates for mass production by industry (Domestic Policy Review, 1978-1979) were set for the following applications:

- o utility electric power - $1300/kWe by 1985-87,
- o total energy/cogeneration - $1000/kW (electric and thermal) by 1983-84,
- o industrial process heat - $9-11/MMBtu by the early 1980's.

In 1980, the cost-performance measure was converted to "total annual cost per annual output" (Table 1) to provide a standard basis for comparing proposed designs. Cost targets reflect the value of competing conventional energy systems in the Southwest and are deemed achievable at concentator production volumes of about 1,000,000 m^2/year per factory. Dates reflect the completion of such factories. The cost-performance objectives imply a complete set of specific cost and performance measures associated with subsystems and components (Table 1 lists important items).

Other renewable technologies address subsets of the same market sectors as STES; but the wide temperature ranges and capacity levels of STES make it more broadly adaptable to major energy sectors, such as electricity generation, IPH and transportable fuels/chemical feedstocks production, than the other renewables. Also, the use of cheap efficient thermal storage gives STES a competitive edge over other solar electric systems in energy cost, potential fuel savings and matching the demand requirements of users.

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* Also in 1974, Congress passes the Federal Non-nuclear Energy Research and Development Act (P.L. 93-577), the Solar Heating and Cooling Demonstration Act (P.L. 93-409), and the Energy Reorganization Act (P.L. 93-438). These acts contributed to the creation of the Federal solar thermal program.

The DOE has assumed world leadership in STES R&D and is coordinating its program with complementary private U.S. programs (i.e., the Electric Power Research Institue and the Gas Research Institute). The STES Program has cooperative agreements with the International Energy Agency, Spain, Italy, and Saudi Arabia, but actual competition from foreign companies is building with help from their governments. The European Economic Community, the Federal Republic of Germany, France, Italy, Brazil, Japan, Israel, and the USSR are all constructing pilot systems. These nations also plan to export to the U.S. and other markets.

Other industrialized nations are proceeding with their development of solar thermal technology. An alternative to continuing this Federal program would be for the United States to become an importer of future foreign research and development accomplishments and solar thermal products. This alternative is somewhat analogous to our experience with high imports of fuel-efficient compact cars during the 1970's.

PROGRAM IMPACTS: The Program has made significant progress, but substantial work remains. Major field tests are on the verge of generating valuable operating data: Table 1 highlights accomplishments by Congressional objective, budget and annual activity.

For 2 years, a parabolic trough system has reliably producted 150 kWe. More than a dozen experimental parabolic trough systems have produced heat in the 200-500°F range, many of which have a 10 million Btu/hr capacity. The world's largest (10-MWe) solar thermal central receiver power plant will begin operation in 1982; and second-generation component tests are underway. Higher-temperature central receiver systems have been designed, but testing of major components lies ahead. The first parabolic dish total energy facility will be operational in 1982. Hybrid systems are being developed using Brayton or Stirling engines with parabolic dishes: a preliminary design for a .25 to 1-MWe system has been completed.

The Program has assembled teams of scientists, engineers and managers at private firms, universities, and national laboratories from all regions of the U.S. A recent survey shows that potential suppliers have borne about 25% of STES R&D costs, as a direct result of this Federal program.

The high payoff potential of solar thermal technologies is inherent in their ability to be deployed along or supplement existing oil- and gas-fired facilities while lowering energy costs; to produce heat at the 250-2,500°F temperatures required in U.S. energy markets; and to be compatible with affordable thermal energy storage.

Potential program beneficiaries include suppliers and customers who produce and use STES. Suppliers include component producers and installing/integrating firms. The first customers will be located in high insulation and/or high fuel price regions, and include municipal and investor-owned electric utilities, rural electric cooperatives, military bases, IPH users, users of diesel power for irrigation, and users of energy equipment for enhanced oil recovery purposes.

Program benefits are anticipated in the electricity sector where STES can displace conventional fuel (petroleum and natural gas) and potentially reduce operations and maintenance (O&M) costs. If cost objectives are met, the potential net savings in the utility industry alone for systems installed in 1990 ae estimated at $15-$25 billion (1981 $).* Because neither storage nor IPH applications are factored in, total potential net savings are larger.

In the long-term, the U.S. will benefit from reduced dependence on foreign oil anc greater flexibility during price/supply disruptions by STES effectively establishing a ceilng on prices that utilities and industry would pay for oil/natural gas in each region of the country. Large-scale deployment of STES will therefore reduce the inflationary pressures on the economy and provide a range of entrepreneurial opportunities.

Environmentally, compared with conventional systems, STES emit less air pollutants and can enhance industrial growth in areas restricted by air pollution standards. In the long-term, atmospheric CO_2 buildup is reduced. Health and safety dangers appear minimal.

PROGRAM REQUIREMENTS: Research objectives will continue to address long-term R&D needs that now preclude industry from developing cost-competitive STES. The 1983 to 1988 Program should: 1) complete the 10 MWe central station receiver operation and provide R&D support for industry initiatvies in central receiver scale-up/repowering; 2) complete near-term trough R&D and transfer technology to industry/users; 3) field test industrial parabolic dish designs in user environment at a meaningful scale to prove technical feasibility; 4) establish technical feasibility of bulk hydrogen production processes; 5) verify the operating prinicples of large-scale solar electric ponds through the construction and test of a 5 MWe prototype (Over 80% of recently surveyed STES suppliers support much of this emphasis; also, they felt full-scale systems tests and user applications need more Federal support.).

In spite of significant progress toward increased performance and lower cost of this technology and in fostering an industrial base, continuing Federal R&D is needed. In a recent survey of industry, suppliers were asked for their response to program termination: 10 firms (20%) would have to reduce their R&D commitment and 22 firms (45%) would have to stop altogether.

The magnitude and complexity of the technical accomplishments required to achieve economic viability are such as to preclude R&D investment by suppliers or by utilities in the near future. Private risks are too high in relation to private costs. The Solar Energy Industries Association has said that " . . . significant Federal involvement is needed for the technial validation of solar thermal technology . . . The supply industry cannot afford both the investment in trained personnel and capital equipment, and the funding for this long-term R&D."

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* Potential discounted net present value of solar thermal systems likely to be installed in 1990 when the cost targets of $1400-$2100/kW (1981 $) are met. (Assumes NEP III medium case nominal assumptions for fuel prices.)

The expected program results depend on future funding levels. Long-term program R&D needs are described in Table 2.

DISCONTINUATION ROUIREMENTS: If a termination decision is made by mid-FY 1982, the Administration should request a FY 1983 appropriation of between $20 and $50 million, depending on the timing, to minimize both disruptive effects and future Federal costs. This covers (1) close down costs for facilities at national laboratories and universities, and (2) existing private sector and foreign government obligations (i.e., operating/evaluating 10-MW Barstow plant, Shenandoah project, IEA systems in Spain, and several IPH experiments).

Termination disruptions, based on results of a 1981 survey of STES contractors, would include the loss of 45% of U.S. firms now involved in solar thermal research and development. This would delay commercial viability for at least a decade.

TAB "1

BIOMASS ENERGY SYSTEMS PROGRAM ACCOMPLISHMENT

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	Program Accomplishments, by year, by program element				DEGREE ORIGINAL OBJECTIVES MET
		FY 78	FY 79	FY 80	FY 81	
		$21.4	$41.9	$32.0	$31.0	
For Entire BES Program:	Duplicative:	Thermochemical:	Thermochemical:	Thermochemical:	Thermochemical:	For Entire BES Program:
• Additional 0.5 to 1.5 Q/yr. from biomass by 1985 • Additional 6 Q/yrs. by 2000 • Total of 10 Q/yr. after 2000	None	• Began operation at Albany direct liquefaction facility • Synthesis gas from manure (SGFM) reactor in operation (pyrolysis). • Start bench scale catalyzed steam gasification.	• Bench-scale multi-solid fluid-bed gasifier tested. • Startup of 3 ton/day Garrett gasification process development unit (PDU). • Startup of PDU for the study of catalytic conversion of biomass feedstocks.	• Tested direct-fired combustion module using green wood • Startup of test unit for aqueous liquefaction process for wood.	• Successful operation of a 3 ton/day Multi-solid fluid bed gasifier to produce Medium-Btu gas. • Completed construction of green wood direct combustion gas turbine test facility. • Construction of ablative fast pyrolysis process development unit.	• Estimates indicate additional 1.1 Q/yr of energy from biomass by 1985. • Estimates indicate 2.9 Q/yr. additional energy from biomass by 2000 at current funding levels. • Estimates indicate a level of 12.0 Q/yr. from biomass by 2010 at current funding levels.
		Biochemical:	Biochemical:	Biochemical:	Biochemical:	
		• Completed design and feasibility study for an anaerobic digestion test facility at Bartow, Florida.	• Completed construction of a Plug Flow Reactor Dairy Digester.	• Completed evaluation of Plug Flow Dairy Digester.	• Transferred Bartow facility to the private sector. • Definition of the nutritional regimes for methanogens in progress.	

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GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	Program Accomplishments, by year, by program element				DEGREE ORIGINAL OBJECTIVES MET
		FY 78	FY 79	FY 80	FY 81	
		$21.4	$41.9	$32.8	$31.0	
		• Demonstrated 30% increase in gas yields from corn stoves due to pretreatment • Development of micro-organism strains that increase alcohol yields from biomass conversions.	• Initiated construction of an anaerobic digestion facility for a 10,000 head feedlot. • Initiated testing of a farm scale crop residue digestion system. • Initiated conceptual design for a 3 ton/day experimental fermentation unit for a 3 ton/day experimental fermentation unit.	• Identified the economic viability of feedlot manure digesters. • Initiated bench-scale tests of improved techniques for digesting crop residue. • Completed construction of Bartow facility for 10,000 head feedlot. • Compared biogas produced from on-farm manure digesters to propane & fuel oil.	• Identification of operating parameters for a biomethanation system. • Assessed the economic and technical feasibility of converting secondary residues to biogas.	
		Photobiological: • Initiated search for stable electrodes for producing H_2 by water-splitting.	Photobiological: • Achieved sustained production of H_2 using blue-green algae.	Photobiological: • Isolated photosynthetic bacteria to achieve hydrogen evolution rates comparable to green & blue-green algae.	Photobiological: • Identified species of green algae with high hydrogen production potential.	

TABLE 1

BIOMASS ENERGY SYSTEMS PROGRAM ACCOMPLISHMENT

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	Program Accomplishments, by year, by program element				DEGREE ORIGINAL OBJECTIVES MET
		FY 78	FY 79	FY 80	FY 81	
		$21.4	$41.9	$32.0	$31.0	
		Short-Rotation Woody:	Short-Rotation Woody:	Short-Rotation Woody:	Short-Rotation Woody:	
		• Initiated 25 regional field experiments, for species selection.	• Conducted species selection research on 80 species & hybrids within these species.	• Established performance evaluation field research plots in 36 native wetland stands of potentially fast growing woody species in the Western Lake States.	• Screened 25 species for further study out of 40 species which were considered to have potential for high productivity under short-rotation culture.	
		• Built & tested 2 prototypes of a commercial clear cutting harvester.	• Obtained preliminary results of survivability & the annual growth rate of selected species in stand establishment experiments.	• Completed preliminary selection of desert shrub species based on best biomass production after two years growth in the semi-arid Southwest.	• Demonstrated productivity rates of over 5 dry ton/acre/year in field plot experiments at different regional locations in U.S.	
				• Selected for further study best clones of black cottonwood and other Populus hybrids in the Pacific Northwest.		

TABLE 1

BIOMASS ENERGY SYSTEMS PROGRAM ACCOMPLISHMENT

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicating)	Program Accomplishments, by year, by program element				DEGREE ORIGINAL OBJECTIVES MET
		FY 78	FY 79	FY 80	FY 81	
		$21.4	$41.9	$32.0	$31.0	
		Aquatic:	Aquatic:	Aquatic:	Aquatic:	
		• Established 1/4 acre test module for sea kelp.	• Completed cost analysis of aquatic biomass systems. • Screened species and tested nutrient requirements of aquatic plants.	• Started preliminary survey on oil yields from marine microalgae. • Constructed raceway for growing marine microalgae.	• Isolated a nitrogen-fixing blue-green alga that has high potential for replacing fertilizers produced from petrochemicals. • Completed construction of the first fresh water oil-producing microalal raceway production system. • Transferred off-shore kelp project to private sector.	

TABLE

BIOMASS ENERGY SYSTEMS
CURRENT PROGRAM OBJECTIVES & BUDGET
(Budget data on FY82 dollars; millions)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS	BUDGET JUSTIFICATION & SERVICES PROVIDED
R&D to increase conversion efficiency and meet cost objectives for gaseous and liquid fuels and petrochemical substitutes. Technologies and their specific objectives are:	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Develops technologies to convert biomass to energy to meet cost objectives by increasing conversion efficiency.	
• Thermochemical conversion to reduce costs of liquid and gaseous fuels and chemical feedstocks. Quantitative objectives are to reduce costs per MMBtu from $3.50 to $28 now to $3 to $7 by early 1990's.	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Accelerates advancement of the technology through lab scale, bench-scale, PDU, up to the point where the private sector can and will take over.	Budget FY82 $7.1 Estimated Outyear Costs $14.7 • Production of medium-Btu gas by technologies using heat, pressure, and/or catalysts from a variety of biomass sources.
• Biochemical technology (e.g., anaerobic digestion) for conversion of biomass into petrochemical substitutes: to reduce cost of biogas to $4/MMBtu by 1990.	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Develops methods and equipment for preparation of biomass feedstocks for conversion.	Budget FY82 $2.1 Estimated Outyear Costs $10.3 • Development of technology for conversion of biomass feedstocks to biogas to replace natural gas as fuel.
• Photobiological systems that will produce hydrogen from water and renewable resources: to produce increased supply of hydrogen for fuel and chemical production.	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Solves technical problems such as feeding mechanisms in large-scale conversion.	Budget FY82 $1.4 Estimated Outyear Costs $8.6 • Development of biological systems and technology to maximize production of hydrogen to various species of biological organisms.

[1] Specification of quantitative objectives for these program elements is not realistic since many projects are exploratory research expected to yield substantial payoffs, but not before 1995.

TABLE

BIOMASS ENERGY SYSTEMS
CURRENT PROGRAM OBJECTIVES & BUDGET
(Budget data on FY82 dollars; millions)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS	BUDGET JUSTIFICATION & SERVICES PROVIDED
Identify & develop innovative biomass feedstocks without adverse effects on traditional food and fiber markets. Includes development of:	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Expands the herbaceous, woody and aquatic biomass resources base and emphasizes use of currently underutilized arid and marginal lands.	
• Herbaceous energy systems (e.g. to increase productivity of hydrocarbon plants grown on arid lands & grasses on marginal lands.	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Identifies species capable of biomass production that can be converted into energy by conversion technologies being developed.	Budget FY82 $2.0 Estimated 5 year Costs $8.6 • Production of increased biomass from herbaceous sources by identification of high yield species and improved methods.
• Short-rotation woody crops (to increase annual yields from current average yields (from forestry) of 1.5 dry tons/acre-year to 8 dry tons/acre-year by 1992).	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Develops optimal growth strategies and production systems, and identifies nutrition requirements of each species.	Budget FY82 $4.0 Estimated 5 year Costs $20.6 • Maximization of wood biomass without competition with traditional wood industries.
• Aquatic systems (to identify, improve and develop promising species of microalgae, macroalgae, floating plants, and emergent plants such as cattails.)[1]	• Reliance on private sector only • Use of incentives, e.g., tax credits • Use of regulations or standards • Elimination of all energy-related subsidies	• Develops harvesting methods, timing, and equipment appropriate to each type and species of biomass.	Budget FY82 $2.3 Estimated 5 year Costs $9.3 • Development of viable energy producers with sustained yields.

[1] Specification of quantitative objectives for these program elements is not realistic since many projects are exploratory research expected to yield substantial payoffs, but not before 1995.

TABLE 1. SOLAR THERMAL ENERGY SYSTEMS PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (duplicative)	BUDGET DATA ($millions) STATUS FY 78 104.1	FY 79 117.2	FY 80 143.2	FY 81 130.3	DECREE CRITICAL OBJECTIVE MET
PRODUCTION OF ELECTRICITY FROM A NUMBER OF POWER PLANTS ON THE ORDER OF 1-10 MWe EACH:						
o 50-100 mills/kWh by 1990's - Central Receivers o System capital cost $1000-$2300/kWe o Heliostat cost $84/m² for glass o Receiver cost $50/kWe - Parabolic Troughs	o European Economic Community, Japan, Israel and USSR central receiver programs. o EPRI central receiver/Brayton technology development (complementary to STES Program effort).	o Central Receiver Test Facility (CRTF) construction completed. o Shallow-well parabolic trough project in operation.	o Heliostat design with $200/m² cost in production tested. o Confirmed performance of first-of-a-kind heliostats and EPRI/Boeing receiver at 1MWe.	o Heliostat field at CRTF maintained at or above 95% operational level. o Confirmed performance of 10-MWe receiver panels. o Deep-well parabolic trough project in operation for 1 year. o Distributed focus (bowl) collector in operation.	o Completed construction of 10-MWe Barstow Pilot Plant. o Tested small scale molten salt receiver and storage concepts, and heliostat design with $100/m² cost in production.	Engineering feasibility of several options will be completed within next two years. If present rate of progress continues for next five years all objectives can be met.
PRODUCTION OF SYNTHETIC FUELS IN COMMERCIAL QUANTITIES: o Identify feasible processes o Prove commercial feasibility processes	(none)	o Fuels and chemicals project at Georgia Institute of Technology in operation.	o Completed experiments on oil shale retorting and coal gasification using solar. o Developed conceptual designs for solar thermal production of hydrogen.	o Demonstrated conversion efficiency of 50% for Solchem receiver. o Reports on 1390 processes reviewed. o Completed feasibility experiment for fuels and chemicals production.		A number of candidate processes have been identified. Program is on track to achieve technical feasibility by 1986.
UTILIZATION OF THERMAL AND ALL OTHER BY-PRODUCTS OF SOLAR FACILITIES:	(none)		o 9 thermal dish collectors for Shenandoah tested.		o Shenandoah total energy project construction completed	Ready to operate system for a number of years.
DEVELOP HYBRID AND SMALL COMMUNITY POWER SYSTEMS: o 50-100 mills/kWe by 1990's - Parabolic Dish o system efficiency 25-30% o system life 30 years o concentrator cost $80-120/m² o receiver cost $20-85/kWe o power conversion cost $120-230/kWe	(none)			o Confirmed performance of steam receiver. o Constructed parabolic dish test site (PDTS). o Test bed concentrators at PDTS achieved energy flux equal to 14000 suns.	o Completed development of an ORC parabolic dish power module. o Confirmed performance of dish Stirling concept at PDTS. o Confirmed performance of solarized Brayton engine. o Confirmed performance of air receiver.	Concentrators in development. 20% efficiency possible with 3 engine options 30% efficiencies using either a Brayton or Stirling engine with ceramic components.
LARGE-SCALE UTILIZATION OF SOLAR ENERGY FOR DIRECT HEATING: o 85-87/MMBtu by 1990's o 4.0 MMBtu/m²-yr o average annual efficiency 45% o system life 20 years	o GRI/IPH Program (complementary to STES Program effort)	o Confirmed performance of trough made of sheet-molding compound.	o Peak efficiency corresponding to 1995 target met. o Commercial collectors demonstrated 1986-1985 objective.	o Seven IPH projects in operation for one year. o Five new IPH projects in operation.	1980 objectives have been accomplished. Program is progressing towards future objectives.	

Table F. NEEDED ACCOMPLISHMENTS TO ACHIEVE PROGRAM OBJECTIVES

PROGRAMMATIC OBJECTIVE *	ANTICIPATED NEEDS	BUDGET JUSTIFICATION
FOR UTILITY-SCALE ELECTRIC CENTRAL RECEIVER (CR) SYSTEMS:		
• Proof of technical feasibility of heliostats, receivers and storage subsystems with potential to meet cost targets. • Proof of feasibility of the CR concept based on Barstow Pilot Plant and foreign experiments.	By 1985 • 2-year or more testing of prototype subsystems; • Material compatibilities research; and • Confirmed subsystem cost projections. By 1984-87 • 2- to 5-year testing; and • 100-MW system cost projection linked to experience at 10-MW and 1-MW.	• Central receiver technology development. • Materials research, applied research and advanced thermal storage. • System test and evaluation of Barstow 10-MW electric pilot plant.
FOR SALT-GRADIENT SOLAR POND ELECTRIC POWER PLANTS:		
• Proof of large-scale solar ponds operated efficiently, reliably and economically.	By 1988 • 2-year operation of 5-MW (50 acre) power system at Salton Sea and 4-year operation at Dead Sea; • Cost estimates for full-scale 20- to 50-MW modules for Salton Sea Power Plant; and • Regional tests of 500-kW to 1-MW ponds.	• Development of components and subsystems for solar ponds. • Initiate Salton Sea power plant construction
FOR LARGE-SCALE DIRECT HEATING SYSTEMS AND THOSE USING THERMAL BY-PRODUCTS:		
• Proof of feasibility of systems using parabolic dish technology at low temperature.	By 1983 • 1-year testing of solar total energy system at Shenandoah and PEI collector design at Capitol Concrete in Topeka, Kansas.	• System test and evaluation of Shenandoah. • Develop low-temperature parabolic dishes.
• Technical readiness of IPH compatible receivers, storage for use with central receiver	By 1984 • Tests of 5-MW class subsystems at CRTF.	• Develop receivers for IPH.
FOR SOLAR FUELS AND CHEMICALS:		
• Proof of technical feasibility.	By 1986 • Test of fuel or chemical production at CRTF.	• Systems requirements for Sunfuels.
FOR SMALL-COMMUNITY ELECTRIC HYBRID FUEL/SOLAR POWER SYSTEMS:		
• Establish feasibility of 20-kW modules at 29% solar-to-electric efficiency. • Establish feasibility of 20-kW modules at 30% solar-to-electric efficiency.	By 1994 • Extended testing of ORC, Brayton and Stirling engines with high-temperature parabolic dishes. By 1988 • Success in the Automotive Program with either Brayton or Stirling engine improvement programs; and • Tests of adapted versions of advanced automotive engine with parabolic dish.	• Develop parabolic dish technology, including organic Rankine and Stirling engine test. • Develop solarized version of Brayton engine with ceramic components.

*These programmatic objectives are on the critical path to the cost targets listed in Table 1.

OCT 6 1981

PROGRAM: Solar Power Technology

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

The Solar Power Technology Program sponsors research and development of two solar technologies which have as their primary purpose the generation of electricity: wind and ocean energy. The emphasis has been on systems with the potential for applications in the utility sector; including investigation of the problems of integrating wind and ocean technology with existing electric generation and distribution sytems. Since wind machines are already being sold commercially for special applications, the program has focused on research to make wind technology more competitive with conventional energy systems. Ocean energy research, on the other hand, has been primarily aimed at demonstrating the technical and economic feasibility of ocean thermal energy systems.

WIND ENERGY SYSTEMS

Program Objectives

The Wind Energy Systems Program provides the Nation with the opportunity for increased production of electricity from wind energy sources. The utilization of wind energy conversion systems will result in an immediate reduction in the demand for existing non-renewable energy supplies.

Federal involvement in a wind energy program began with a small technology development program at the National Science Foundation in the early 1970's. In 1974, the program was transferred to the Energy Research and Development Administration's (ERDA) under the Solar Energy Research, Development and Demonstration Act of 1974 (P.L. 93-473). ERDA was provided with increased authority under the Federal Non-Nuclear Energy Act of 1974 (P.L. 93-577). With the establishment of the Department of Energy in 1977, the Federal wind energy program grew to become a multi-faceted program that addresses all aspects of wind energy conversion system development; including research, development and demonstration as well as non-technical and commercialization support activities.

The program received a congressional mandate "to establish during the next eight years an aggressive research, development, demonstration and technology applications program for converting wind energy into electricity and mechanical energy" with the passage of the Wind Energy Systems Act of 1980 (P.L. 96-345). This act quantified the historical goals of the program as shown in Table 1. Specific objectives of the current program, as shown in Table 2, continue to be responsive to this legislation and are consistent with the administration's goals of high risk, high payoff research and development.

The achievement of these objectives is truly a national effort and elements of various governmental agencies contribute to the DOE wind program. The Bureau of Reclamation in the Department of Interior has purchased and is installing two large wind turbines for integration and testing with the Bonneville Power Administration hydroelectric system. The Department of Transportation is working with the Rocky Flats Test Center in testing small wind turbines on their controlled velocity test facility track. The Departments of Agriculture and Defense are participating in operational experiments and test applications with small wind machines. However, only the DOE program funds research and development activities.

Continued Federal involvement in the development of wind energy systems is structured to provide the wind system industry with basic technological expertise to allow for private sector production and sale of economical and reliable wind turbines. The types of R&D programs being funded historically have not been pursued by the private sector due to competitive demands on working capital and the need for a short-term return on investment. Alternatives to the current federal wind energy R&D program include heavy subsidies, strong regulatory programs that mandate the use of wind energy systems, and governmental involvement in user purchases through the establishment of federal manufactring and hardware standards. These alternatives, however, are considered less cost-effective than the existing R&D program

Program Impacts

Program objectives are being achieved through broad, comprehensive research, development, and demonstration efforts. Small wind machine prototypes are being field tested in seven states. The installation of 114 commercial machines is being accomplished in 56 states and territories. Industry testing programs are carried out on a cost-shared basis at the Rocky Flats Test Center. These and other efforts have resulted in the achievement of a 6-13 cents/kWh cost-of-electricity for small wind turbines depending on machine design, operating conditions, and production quantity.

Thirteen large wind turbines (greater than 100 kW) have been installed and are producing nearly 20 MW of wind generated electricity. Three of the largest wind turbines in the world (the 2.5 MW MOD-2) are operating and interfaced with the Bonneville Power Administration grid. At least five public utilities have begun to consider large "wind farms" in their planning for future capacity. The cost-of-electricity from large wind machines has been reduced to 10-15 cents/kWh. Utility intertie has been demonstrated and machine reliability has improved.

The wind machine industry is generally labor-intensive and localized in characteristically windy areas of the country. Development of an industry capable of achieving national energy supply goals, e.g., 800 MW by 1988, will require 40 to 60 companies employing 50,000 to 60,000 people. This is slightly less than the number of companies currently involved in the production of wind energy systems, but an increase in production rates of a factor of about 50 is necessary to produce a sufficient number of wind turbines.

Use of wind energy systems has less of an impact on the environment than the generation of that power by the burning of fossil fuels or the use of nuclear power. Only audible noise and infrasound potentially have a detrimental impact on the health of the nation; and then only in the case of widespread use of large wind systems. Careful design and siting virtually eliminate these potential problems.

From FY 77 through FY 81, annual funding for the federal wind energy program has more than doubled. The small wind system industry in the United States has grown from an industry producing tens of machines per year to one producing a few thousand machines per year. The large wind system industry, non-existent in 1977, has developed to the point that it has the capability of beginning to penetrate the utility power generation market. While some mechanical problems and operating deficiencies characterize certain large wind machines, DOE's technical R&D program has made great strides in the development of efficient machine

designs and reliable subsystem components. Field activities have increased consumer interest and confidence in wind-generated electrical power to a point where normal market forces will insure a viable, competitive wind system industry in this country. Major past accomplishments and current objectives of the federal program are outlined in Tables 1 and 2 respectively.

Projected Program Requirements

The federal wind energy program and the private sector have shared in the development of a technical base, economic environment, and institutional framework that has brought the wind system industry to the verge of a competitive position from which normal market forces can now move forward to accomplish program goals. A requirement remains, however, for continuing federal support in high-risk R&D, testing of advanced prototype machines, and research on product improvements.

The current Wind Program budget request is for $18.3 Million in FY 82 and $14.0 Million in FY 83. To meet current program objectives (Table 2) will require $19.4 Million in FY 82 and $22.6 Million in FY 8[illegible] This latter level of FY 82 funding is the President's original request and was predicated on the level of funding necessary to accomplish stated program objectives. The lower level ($18.3 Million) omits certain environmental research (e.g. television interference) and testing of previously developed, advanced technology small wind machines. The President's original request of $20.6 Million in FY 83 was consistent with attaining all program objectives except for research on wind resource assessment, gust loading, and forecasting. An additional $2 Million (total $22.6 Million) would be required to meet these wind characteristic objectives.

A 10% increase over the current level of funding for wind energy activities would have the following effect on the program:

- o establishment of a National Wind Data Center as defined in P.L 96-345 would be initiated;
- o fabrication of medium-scale models of selected innovative concept(s) for exploratory evaluation would be initiated;
- o upgrading of one additional MOD-OA for turnover to a host utility would be undertaken.

At a 10% decrease in level of financial support for the Wind Program would have the following effects:

- o existing analytical models and handbook tools would not be updated to reflect recent knowledge;
- o television interference and wind machine noise research would be eliminated;
- o reliability and long-term testing of previously developed 4 kW and 15 kW advanced technology wind machines would not be conducted.

Discontinuation Requirements

Most Wind Program activities are performed by DOE operations offices, the Solar Energy Research Institute, and national laboratories (Pacific Northwest, Sandia and NASA Lewis). In all cases, wind activities are a small part of the total program for these institutions. An orderly termination to minimize disruptive effects on personnel and institutional policy and directives will require a phase down period of approximately one year along with $ _____ million to terminate existing contractual and in-house efforts. Also, the requirements under the Wind Energy Systems Act of 1980 (P.L. 96-345) would have to be addressed. Some portions portions of the program could be continued by executive or legislative action in other federal agencies such as the Federal Power Marketing Administrations and the Department of Interior.

OCEAN ENERGY TECHNOLOGY

Program Objectives

The Department of Energy's Ocean Energy Technology program seeks to develop technologies that utilize the large supplies of renewable energy in the world's oceans. Energy can be captured from ocean waves, currents, salinity gradients and, most importantly, by exploiting the thermal gradients which occur between different depths using a process called ocean thermal energy conversion (OTEC). The goal of the Ocean Energy Technology program has been to develop options for extracting and distributing significant amounts of this ocean energy in a reliable, environmentally acceptable, and cost-effective manner.

To accomplish this, DOE set forth a strategy to achieve the following objectives (see Table 1 for details):

1. to determine basic ocean thermal resource and environmental data required for site selection and plant design;

2. to perform R&D aimed at technology improvements that reduce risk and improve performance sufficiently to permit the private sector to construct ocean energy systems; and

3. to promote market development for diverse classes of ocean energy systems by increasing user awareness/acceptance, by encouraging expansion of manufacturing capabilities and by reducing barriers to commercialization.

In July 1980, Congress established specific national development goals (see Table 1) for the most promising of the ocean energy systems, OTEC, in the Ocean Thermal Energy Conversion Research, Development and Demonstration Act (P.L. 96-310). As a result of this legislation, the DOE Ocean Energy Technology program established a fourth program objective:

4. to assist the private sector in the attainment of the national goals established in P.L. 96-310.

Other legislation provides Federal financial incentives to further the commercial prospects for OTEC, and allow private industry to build on the results of the Federal research and development effort. The Ocean Thermal Energy Conversion Act of 1980 (P.L. 96-320) established a one-stop licensing authority administered by the National Oceanic and Atmospheric Administration (NOAA) and provided for the extension to OTEC plants and plantships of construction loan guarantees administered by the Maritime Administration. In addition, the Crude Oil Windfall Profits Tax Act of 1980 (P.L. 96-223) provides an energy tax credit of 15% (in addition to the existing investment tax credit of 10%) for OTEC plants in two locations.

Program Impacts

Although considerable progress has been made toward the attainment of all OTEC program objectives, ocean power technology has not experienced widespread commercialization and, therefore, it is possible only to make projections of ultimate impacts on the national economy, the environment, etc.

Regarding the first objective listed in Table 1, OTEC has been identified as possessing a large domestic and global renewable energy resource. Although the size of the worldwide resource available has never been calculated, one study estimated that 18.8 - 38.4 quads per year are available in the Gulf of Mexico off the United States, Puerto Rico, and the Hawaiian Islands.[1] Site-specific OTEC resource data have been obtained from satellite imagery, surveys, and on-site measurements for locations in the Gulf of Mexico and the South Atlantic, and off the coasts of Puerto Rico and Hawaii. Ten world site studies based on archival data have also been completed and a worldwide thermal resource map has been constructed from existing data.

The Ocean Energy Technology program has also made substantial progress toward achieving its second objective. Conceptual design studies have been completed for six different OTEC plant concepts, and conceptual and preliminary design studies have been conducted on the cold water pipe, power systems, electrical cable systems, and mooring and positioning systems. Technical feasibility of a complete OTEC power generation system was demonstrated by Mini-OTEC, a 50kWe gross (10 kWe net) experimental vessel funded by private industry and the State of Hawaii. Larger-scale ocean-based test programs, such as the OTEC-1 sea-based engineering test facility, have proved the technical feasibility of OTEC components and subsystems at a significant scale. Successful operation of OTEC-1 was a major step in demonstrating the viability of large-size heat exchangers. Substantial progress was also made in resolving the issues associated with the structural integrity of cold water pipes and transmission cables (see Table 1).

In partially fulfilling its third objective, the Ocean Program has obtained a good understanding of the economic, institutional and commercial factors that will affect OTEC integration into various potential markets, including the electric power, aluminum, and ammonia industries. Substantial interaction with decision makers in these possible user communities, as well as with potential OTEC producers (such as shipbuilders and component manufacturers) has led to the conclusion that there are no major barriers to early industrial development. Also, technical and economic feasibility of an integrated OTEC system (of a size that can be reasonably scaled to that of a commercial plant) is currently being explored in the conceptual design program.

Since the Ocean Energy program is in the early stages of hardware development, it has had only a limited impact on the national economy. Still, several hundred companies throughout the nation have participated in OTEC research and development. Also, attainment of the national goals contained in P.L. 96-310 would result in a much larger economic impact. Preliminary analyses indicate that a level of industrial activity compatible with the goals of P.L. 96-310 would result, by 1999, in the creation of approximately 144,000 permanent jobs, and would provide $60 million annually in Federal tax revenue from annual sales of $11.4 billion. This projection, moreover, only reflects the U.S. domestic market. The economic impacts would be much greater if the effects of technology export were considered. All of these potential economic benefits, however, are predicated on a level of Federal financial support sufficient to catalyze them.

Although the net environmental impacts from OTEC development are expected to be much more positive than the impacts associated with other baseload power sources, certain negative environmental effects are possible. Most of these potential impacts center on the marine ecosystem since ocean water is the source of the evaporating and condensing waters as well as the receiver of OTEC plant effluent. Environmental concerns that have been studied thus far include: impingement and entrainment of marine biota, ocean water mixing, sea surface temperature perturbations, biocide release, working fluid leaks and platform attraction.

Projected Program Requirements

No FY 82 funds have been requested for this program.

Discontinuation Requirements

Under the Ocean Thermal Energy Conversion Act of 1980 (P.L. 96-320), DOE is charged with responsibility for the regulation of OTEC demonstration facilities and with providing advice to the Secretary of Commerce regarding the technical and economic soundness of applications for Maritime Administration loan guarantees for OTEC facilities. Unless P.L. 96-320 is repealed or amended, DOE must maintain the technical expertise to carry out these responsibilities or provide for the transfer of responsibility to another agency, e.g., Maritime Administration, U.S. Coast Guard.

The DOE also must provide a small technical staff to complete on-going efforts, and to organize the orderly transfer of the technology to the private sector. Total manpower required for this task is estimated at three full time personnel. No appropriation has to be made.

TABLE I

WIND ENERGY SYSTEMS PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	FY78	FY79	FY80	FY81	DOERR ORIGINAL OBJECTIVE MET
		34.5	59.6	60.7	54.6	
I. To prove the feasibility of large wind systems and to develop reliable long-lived and economically viable small and large wind machines:	NONE			Reliability, fatigue lifetime, maintenance studies conducted, power quality, safety, stability and interconnection issues addressed	Component development, product improvement tests at Rocky Flats	Technical feasibility of wind energy systems has been well established at all system sizes
◊ To develop and test a series of small turbines in the 1-100 kW class.		1,2,8 and 40kW machines developed	4 and 15 kW machines developed. Four low cost Darrieus developed	Tests started on commercial machines at Rocky Flats		Nine small machines under test 1979, 80, 81. Prototypes field tested in 7 states
◊ To develop and test intermediate scale MOD-OA, 200 kW systems and large machines in the megawatt range.		MOD-OA tested at Clayton, NM and Culebra, P.R.	MOD-OA tested at Block Island, R.I. MOD-1 (2 MW) installed at Boone, N.C.	MOD-OA tested at Oahu, H.I. First MOD-2 (2.5 MW) installed at Goodnoe Hills, WA.	3-unit MOD-2 cluster installation completed at Goodnoe Hills, WA.	Four intermediate and four large machines under two year tests by 1981. 13 Federal/private machines in operation (total 20 MW)
◊ Complete design, fabrication and testing of advanced multi-megawatt systems by 1984					Multimegawatt MOD-5 conceptual designs started	MOD-5 designs to be completed by FY82. Fabrication/ testing cancelled.
II. To develop basic wind resource information and related models/ analytical techniques for use in siting design and operation of wind systems:	NONE		Blade development efforts, dynamic loads studied. Six innovative concepts studied by SERI		Diffuser augmented turbines studied.	
◊ Produce U.S. wind atlas by 1981			Northwest Region wind Atlas published		Publication of 12 wind atlases completed	National Wind Resources Atlases published for all 50 states and U.S. territories.

TABLE I

WIND ENERGY SYSTEMS PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	FY78	FY79	FY80	FY81	DOE/RE ORIGINAL OBJECTIVE MET
		34.5	39.6	60.7	54.6	
• Develop preliminary wind prospecting and forecasting methods by 1982, refined by 1985						Easy access through a data center for research on data reduction, compilation and storage techniques by FY82. Meteorological compendia for system design and forecasting published by FY 82.
• Develop preliminary machine siting methodology by 1982, refined by 1985				Siting assistance program initiated	Installation of wind measurement equipment completed at 35 utility sites	Siting handbooks published for large and small systems
To promote market development for large and small wind systems by developing the industrial base, increasing user awareness/acceptance, and reducing barriers to commercialization:	NONE					Program element was phased out in FY81. Commercialization strategies have been developed. 20 to 40 small wind system firms and 6 to 8 large wind system firms actively marketing machines. Small wind machine sales at a few thousand annually as a result of tax incentives and maturing technology.
• Undertake studies to identify and ameliorate barriers to wind power application by 1981		LWECS siting handbook for EMI published	Technical and economic models developed	Models expanded to include a broader class of users. LWECS market analysis completed. LWECS guide for utilities completed.	Noise, TVI effects of large wind turbines analyzed.	
• Sponsor and conduct workshops, meetings promotional activities on wind energy development each year		Wind Workshop III held Oct. 1977	User outreach program initiated	Wind Workshop IV held Oct 1979	Two public meetings on P.L. 96-345 held. Workshops held at Rocky Flats, NASA Lewis and Pacific Northwest Labs.	

TABLE 1

WIND IMPACT SYSTEMS PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (IMPLICATIVE)	FY78	FY79	FY80	FY81	DOCKET ORIGINAL OBJECTIVE MET
		34.5	59.6	60.7	34.6	
IV. Objectives of P.L. 96-365	NONE					
• To reduce the average cost of electricity produced by installed wind systems, by the end of FY1988, to a level competitive with conventional energy sources (approximately 3.5-5.¢/kWh for production units in 1980 $'s.					Comprehensive Program Management Plan submitted to Congress. Loans/Grants Program Procedures developed Foreign Applications study completed. Federal applications study completed.	Small machine cost of electricity range 6-13¢/kWh depending on operating characteristics and production rates. Large machine cost of electricity range 10-15¢/kWh depending on operating characteristics and production rates. Operational availability approximately 50% (varies widely among machines) 80 MW, 10 MW, 4 MW and 600 kW wind farms being planned by private sector. 2-megawatt scale and 3-hundreds of kilowatts scale machines have been purchased by private utilities. Private sector-financed large machines are being built for tests in utility capacity planning of up to a gigawatt by 2000.
• To reach a total megawatt capacity in the United States from wind energy systems, by the end of FY1992 of at least 800 MW of which at least 100 MW are provided by small wind energy systems.						
• To accelerate the growth of a commercially viable and competitive industry to make wind energy systems available to the general public as an option in order to reduce national consumption of fossil fuel.						
• To displace 1.7 quads of energy per year by the year 2000.						

OCEAN ENERGY SYSTEMS: PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	FY78	FY79	FY80	FY81	DEGREE ORIGINAL OBJECTIVE MET
		$36.0	$38.2	$43.0	$34.6	
I. To determine basic ocean thermal resource and environmental data required for site selection and plant design.	NONE	Generated global OTEC resource maps.	Compiled detailed OTEC resource data for 5 U.S. locations and 9 int'l. locations. Completed OTEC Programmatic Environmental Assessment.	Collected OTEC resource data at 4 U.S. sites. Completed draft environmental assessment for the Seacoast Test Facility.	Collected OTEC resource data at 4 U.S. sites. Conducted toxicity and impingement studies. (to be expanded by (L. Lewis).	OTEC, wave, and current resources must be defined in greater detail. Observation and testing at site-specific operational OTEC plants are required to further assess the environmental and resource characteristics of OTEC.
II. To perform R&D aimed at technology improvements that reduce risk and improve performance sufficiently to permit the private sector to construct ocean energy systems. Specifically, for an extended period of time to: a. Operate and maintain high performance OTEC heat exchangers. b. Demonstrate structural integrity of cold water pipes in an ocean environment. c. Demonstrate integrity of ocean riser cables in an ocean environment. d. Demonstrate technical feasibility of other ocean energy options: 1) Open cycle OTEC 2) Waves 3) Currents 4) Salinity membrance	NONE	Contractor selected to design and construct OTEC-1 platform. 1 MWth heat exchanger core tested at ANL. Biofouling, heat transfer and corrosion-rate testing conducted near Tampa, Fla. Work began on Seacoast Test Facility in Hawaii. Three organizations selected to design OTEC shell-and-tube power systems.	Completed feasibility design studies of 10 MWe and 40 MWe landbased plants. Conducted at-sea tests of 500 foot cold-water pipe (CWP). Conducted tests of biofouling in waters off Hawaii and the Caribbean. Commenced cleaning tests off coast of Fla. Testing of large heat exchangers developed by industry. Began modification of a Navy tanker and fabrication of heat exchangers for OTEC-1. Three organizations selected to design OTEC power systems based on plate heat exchangers.	Completed four conceptual designs for spar, moored floating, grazing, and landbased OTEC plants. Completed physical model testing of an OTEC pilot-plant. Completed conceptual/preliminary design studies on OTEC CWP, mooring and position-keeping, and electrical-cable subsystems. Installed OTEC-1 heat exchanger test articles and biofouling modules. Achieved partial experimental validation of the CWP computer code.	Completed work on candidate OTEC power system designs. Deployed and successfully operated OTEC-1 engineering test facility. Performed at-sea tests on OTEC-1 to verify feasibility of biofouling cleaning techniques for a 1 MWe shell-and-tube heat exchanger. Started one-third scale at-sea CWP test. Commenced tests of four heat exchanger core units at Argonne National Labs. Commenced first phase of Seacoast Facility biofouling and corrosion test. Completed engineering development tests of electric cable prototype. Substantial progress achieved in developing computer programs for predicting the behavior of candidate ocean platforms, cold water pipes, and power	Observation and testing at site-specific operational OTEC plants are required to further assess the technical, acceptability of OTEC. OTEC heat exchanger performance has been demonstrated but long-term cleanability and performance must be assessed. Structural integrity of OTEC cold water pipes for actual platform needs to be demonstrated at significant scale. Structural and electrical integrity of OTEC submarine electric cable must still be proved in at-sea conditions.

Table 1

OCEAN ENERGY SYSTEMS: PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	FY78	FY79	FY80	FY81	DOE/EE ORIGINAL OBJECTIVE MET
		$36.0	$38.2	$43.0	$34.6	
III. To promote market development for diverse classes of ocean energy systems by increasing user awareness/acceptance, by encouraging expansion of manufacturing capabilities and reducing barriers to commercialization.	NONE	Completed mission analyses that defined potential OTEC markets and permitted the development of market penetration strategies.	Improved cost projections for commercial OTEC systems.	Industry/utilities define commercialization issues.	Defined domestic economic benefit to U.S. of OTEC industrial development.	Identification of early market penetration points and major barriers to commercialization. Assistance to Congress in developing financial incentives.
IV. To assist the private sector in the attainment of the national goals established in P.L. 96-310 a) demonstration by 1986 of at least 100 MWe of capacity from OTEC systems; b) demonstration by 1989 of at least 500 MWe of OTEC capacity; c) for the U.S. Gulf Coast and for U.S. island areas, achievement in the mid-1990's of an average cost of energy from OTEC systems that is competitive with the cost of energy from conventional sources; d) installation of 10,000 MWe (0.7 quad/yr) of commercial OTEC capacity by the year 1999.	NONE			Issued a Program Opportunity Notice (PON) requesting proposals for OTEC proof-of-concept plants.	Began OTEC proof-of-concept conceptual design studies; Documented and disseminated to users the accrued results of program R&D.	

TABLE 2

WIND ENERGY SYSTEM CURRENT PROGRAM OBJECTIVES AND BUDGET
(Budget Data in FY 82 dollars; millions)

Goals/Objectives	Alternative Methods	Anticipated Needs for Objectives (Target Date)	Budget Justification And Services Provided
I. To prove the feasibility of small and large wind systems, to develop technology that will enable the private sector to design and produce reliable and economically viable wind machines; to enable the private sector to achieve the objectives of the Wind Energy Systems Act of 1980 (P.L. 96-345).	Rely on private sector industrial R&D for product improvements, field experiments and system demonstrations on small and large wind machines, and innovative concepts research.	• Conduct research and testing of blades and other advanced components leading to lower cost and improved performance and reliability.	Budget FY 82 15.3 FY 83 19.0 Est. outyear costs: 109.6 • Provide validated analytical tools, validate performance analysis tools, identify technology problems of advanced and innovative concepts, conduct experiments and gather operational data from demonstration machines. Publish fatigue data in 1983.
		• Conduct operational experiments on MOD-0A, MOD-2, and advanced small machines to develop data on blade fatigue, machine stress, machine interactions, and tower resonance, as well as machine performance. Complete conceptual design of multi-megawatt machines in 1981.	Budget FY 82 1.4 FY 83 1.7 Est. outyear costs: 8.7 • Develop an understanding of operations, economics, and environmental questions particularly for utility grid applications. Complete MOD-0A testing by 1983 and MOD-2 by 1984.
II. To develop basic wind resource information and related models/ analytical techniques for use in site selection and in the design and operation of wind systems.	Rely on private sector to develop basic site selection and system simulation models and analytical techniques.	• Refine wind energy prospecting and forecasting techniques. • Develop preliminary siting methodology.	Budget FY 82 2.5 FY 83 2.9 Est. outyear costs: 11.6 • Provide ability to rapidly and economically locate good wind sites. Publish results in 1982.

TABLE 2

OCEAN ENERGY SYSTEMS: CURRENT PROGRAM OBJECTIVES AND BUDGET

Goals/Objectives	Alternative Methods	Anticipated Needs for Objectives	Budget Justication and Services Provided
I. Orderly termination of the program during FY 1982.	N/A	o Determination and payment of contract close-out costs. o Transfer of Federal facilities and activities to appropriate public or private organizations.	Budget FY 82: 0 FY 83: 0

10/6/81

Phase II Sunset Review

OTHER SOLAR PROGRAMS

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

OVERVIEW

Other Solar Programs include the International Solar Energy Program, Solar Information System and construction of a permanent facility for the Solar Energy Research Institute.

INTERNATIONAL SOLAR ENERGY PROGRAM

Program Objectives

There are 16 different public laws passed by the U.S. Congress providing legislative authorizations for DOE to engage in solar (renewable) energy international activities including cooperation with other nations in research and development programs and with other U.S. institutions in carrying out international activities. Principal legislative authority is derived from the Solar Energy RD&D Act of 1974, PL 93-473; the Energy Reorganization Act of 1974, PL 93-438; and the DOE Organization Act, PL 95-91.

The goal of the international solar energy program has been to accelerate the development and use of solar energy technology in the United States and worldwide through joint projects with cooperating foreign countries and through international information exchange and market development.

In consonance with the current DOE policy of concentrating technology programs primarily on high-risk, long-range research and development, the program thrust (goal) will be to implement bilateral and multilateral international research projects, encourage R&D information acquisition and dissemination, and obtain maximum benefits for the domestic R&D programs. The international market development activities have been phased out in FY 1981.

To achieve the current goal DOE, will: accelerate the technical development of selected solar technologies by means of continuing joint international activities under the IEA, U.S./Saudi Arabia and other cooperative agreements and provide solar technical assistance to U.S. government agencies and to international organizations engaged in renewable energy activities.

The historic objectives of the International Solar Energy Program, programs with duplicative objectives, and viable alternative means are shown in Table 1. Current program objectives are included in Table 2.

Program Impacts

Considerable progress has been made toward obtaining system design and operating experience through joint programs R&D with cooperating foreign countries. Under a multilateral IEA agreement with eight other countries, construction was completed in 1981 on two 500 kWe solar thermal systems, located in Almeria, Spain. The United States will obtain operational experience with a distributed

collector system and with a central receiver system based upon a high flux sodium receiver. Two U.S. companies played leading roles in carring out the project. The U.S. contribution is 18 percent of the total project cost of about $40 million. Under one of the bilateral agreements, the United States-Saudi Arabia SOLERAS agreement, a 350 kWe photovoltaic village power system has been constructed and is providing experience in the operation of a large concentrator photovoltaic village system in an arid remote region. The project was carried out by U.S. companies, and the United States contributed one-half of the total project cost. In general, the cooperative R&D projects have industrial involvement and cost-sharing or task-sharing arrangements, are directed to fill domestic program gaps and obtain unique operational experience. Past accomplishments are shown in Table 1.

Direct beneficiaries of these international cooperative projects include the U.S. solar R&D program organizations, U.S. solar industry, foreign governments promoting the use of solar technologies and foreign cooperating institutions. Information acquired through joint cooperative agreements with foreign governments and industries permit the U.S. solar industry to maintain a competitive edge in overseas markets. Although relatively small to date, the increased solar export trade will lead to decreased balance of payment, increased domestic production, development of a stronger industrial base and reduction of the cost of domestic solar systems. In the long term, cooperative international solar energy R&D and information exchange will reduce worldwide dependence on oil and natural gas. The environmental, health and safety impacts are addressed in the solar technology program PAU's as it is considered to be their responsibility.

Projected Program Requirements

The funding request for FY 1982, as shown in Table 2, is $4.0 million. This request, based on a change in program thrust, provides only partial funding for the completion of major existing cooperative programs, mainly the U.S./Saudia Arabia Agreement. Other bilateral and multilateral agreements and projects are being terminated or reduced in scope. The FY 1983-1984 outyear funding of $6.1 million will allow an orderly completion and phase-out of current bilateral and multilateral agreements.

A further reduction in funding of $400 thousand (-10 percent) would reduce the scope or eliminate the SOLERAS agriculture project in a solar-controlled environment.

An increase in funding of $400 thousand (+10 percent) would help ensure that SOLERAS commitments are completed.

Discontinuation Requirements

The SOLERAS agreement, a five year, $100 million cooperative program scheduled to be completed in FY 1983, requires an additional funding of $9.5 million beyond FY 1982. The U.S. share is $50 million. Reduction, termination or extension of this agreement would require renegotiation of the agreement.

If DOE does not continue to provide technical assistance for international solar activities, other Federal agencies, primarily the Department of State, the Department of Commerce, and the Agency for International Development, will have to provide solar technical and economic expertise from within their own staffs (requiring additional staff personnel) or seek support from outside organizations and consultants.

SOLAR INFORMATION SYSTEMS

Program Objectives

The Solar Information Systems Program is designed to share the results of Federal renewable energy programs with the private sector. The program centers around the operation of the Renewable Energy Information Network. Key participants in the network are the Solar Energy Research Institute (SERI), which has lead responsibility for packaging, processing, storage and retrieval of technical solar information; the Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS), which operates an inquiry and referral service in conservation and renewable technologies; the Regional Solar Energy Centers, which provide users with access to solar information services; and DOE headquarters, which provides managerial oversight and program guidance. The basic legislative mandate for the program includes P.L. 93-473, Section 8, the Solar Energy RD&D Act of 1974; PL 93-409, Section 12, Solar Heating and Cooling Act of 1974; PL 93-438, Section 101, Energy Reorganization Act of 1974; PL 95-39, Section 509, National Energy Extension Act of 1977; and PL 96-294, Section 404, The Energy Security Act of 1980.

The broad goal of the program is to transfer the results of relevant solar energy R&D to energy users through an integrated national network and coordinate the solar energy information activities of DOE and other Federal agencies in order to avoid duplication of effort.

Historical program objectives include: (1) establish and maintain solar energy data bases and prepare information products based on user needs; (2) increase the use of solar energy products with satisfied clients; (3) quickly and completely respond to client inquiries; (4) sponsor workshops and seminars to disseminate solar information and (5) coordinate solar information activities of DOE and other Federal agencies. The degree to which these objectives have been met is shown in Table 1. Current objectives are shown in Table 2.

Much of the enabling legislation for the Solar Information Systems Program grew out of an expressed need to accelerate the use of solar energy. Congress recognized that a solar energy information network was vital to the widespread support of the National Solar Program. For example, the use of information from Federal R&D programs has assisted commercially ready technologies, such as passive solar architecture and solar water heating, to be put into immediate widespread use. Information on results of Federal R&D has also provided the vehicle by which new processes and materials have been transferred from laboratories and demonstration projects to commercial applications.

In prior years, the Federal government provided a wide range of fairly general information on solar technologies. The current strategy emphasizes meeting the information needs of high priority users such as the R&D community, followed by the financial sector, equipment manufacturers, architects, and engineers.

There have been a number of solar related information programs in the past with similar objectives. However, most were targeted to specific users and did not duplicate activities ongoing in other areas. A number of alternative methods of meeting program objectives are addressed in Table 2.

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Program Impacts

The solar information systems program has made considerable progress toward achieving the goals of (1) transferring the results of relevant solar energy R&D to energy users through an integrated national network and (2) coordinating the solar energy information activities of DOE and other Federal agencies. For example, since the program began, over 1 million people have been provided timely and accurate solar information. The information provided to network users has contributed greatly to the widespread acceptance of various solar technologies. Manufacturers and builders have increased their sales because of information; builders and buyers have been able to obtain larger loans because bankers understand how to appraise a solar energy system; community and business groups have been able to conduct seminars with only a few weeks preparation because material was available that they could readily adapt for their purpose; homeowners have been able to use information from the government to build and buy solar energy systems; and the scientific and research community has been able to use the latest solar research results to enhance their own efforts. In the area of coordination, the roles of SERI, the RSECs and NSHCIC have been defined and integrated to eliminate duplicate efforts, and an inventory of key DOE and other federal agency information activities was completed. Other program accomplishments are shown in Table 1.

Primary users include the research and development community, architects and engineers, trade associations, state and local organizations, universities and other members of the private sector. The current solar and renewable energy inquiry and referral system handles 4,500 mail and written inquiries per week.

Projected Program Requirements

In FY 1982, $6.7 million has been requested for the program. A 10 percent funding increase in the program would provide for development of technical information products which more nearly meet the users demand. In addition, the program could be expanded to include technical information products (similar to those developed for solar technologies) for hydropower, geothermal, and municipal waste which are not included in the current budget. A 10 percent decrease would result in the elimination of coordination activities. FY 1983-1987 outyear funding of 33.6 million will be requested to continue the program as the same level of services.

Discontinuation Requirements

The major portion of this program is now carried out at SERI and the Franklin Research Center. Termination of the program would require approximately a year's notice to phase out the program. An estimated $500,000 in contract closeout costs would be incurred and a total of sixty people at SERI and Franklin Research Center would be terminated. Arrangements would have to be made by DOE to transfer valuable records (including data bases and response files). Congress would have to be notified of the Department's intent not to comply with existing regulations.

SOLAR ENERGY RESEARCH INSTITUTE CONSTRUCTION

Program Objectives

Establishment of the Solar Energy Research Institute (SERI) was authorized by Public Law 93-473, the Solar Energy Research, Development, and Demonstration Act

of 1974. The Midwest Research Institute, selected through a competitive solicitation to operate SERI under contract to the Department of Energy, began operations in July 1977 in leased buildings.

SERI currently occupies leased space in four office buildings. Since these buildings were built as offices, costly modifications are necessary to efficiently use these buildings as laboratories. Therefore, in FY 1979, DOE supported a budget line item for the construction of a permanent facility. The State of Colorado, in 1977, offered 300 acres of land to the Federal Government for the construction of a permanent facility.

The original objective was to design and construct a permanent facility by third quarter of FY 1981 for approximately 1000 SERI employees that would demonstrate the economic, environmental and aesthetic use of energy conservation and renewable energy technologies. Recently, DOE redirected the role of SERI to one of high-risk long-term research and development. This redirection will result in a reduction in the SERI staff to approximately 500. Therefore, the current objective is to construct new facilities for about 400 laboratory and administrative personnel by the fourth quarter of FY 1985 with some SERI employees continuing to remain in leased office space.

Program Impact

The beneficiaries of the project are the SERI scientists, engineers, researchers and technicians that will occupy the new facility. The result of their research will be made available to industry for use in final product development and marketing. University students will also utilize this facility through exchange programs with the academic community.

The project itself will have negligible impact on the national economy. It will provide a temporary boost to the local construction industry. No significant adverse impacts are expected to the environment.

Projected Program Requirements

The design and construction of the Phase A Field Experimental Test Area and the supporting Field Test Laboratory Building of about 70,000 sq. ft. was funded from prior year appropriations. Before the final design was begun, the role and mission of SERI was redefined, to one of high-risk, long-term research and development. Under the revised role and mission, a reduction in SERI staff is envisioned and it was decided to construct only two of the planned four phases. No additional FY 1982 funding was requested while the role and mission were being redefined.

The outyear funding for FY 1983-1987 of $27.5 million will provide for the design and construction of the Phase B, main laboratory/research facility. This facility will consist of approximately 60,000 gross sq. ft. of laboratory space and about 60,000 sq. ft. of office space.

The currently planned facility will provide for 400 employees and may require a continuation of some leased office space. If less funding (-10%) is provided, a smaller facility could be built requiring more people to remain in leased space. If more funding (+10%) is provided, additional permanent space would be made available for employees that would otherwise occupy leased space. The modular design of the facility should easily accommodate this expansion.

Discontinuation Requirements

If funding for the project is discontinued, SERI will continue to operate in leased space with a reduced ability to attract and retain highly qualified solar energy scientific and technical personnel, and to optimally perform the required solar energy research and development program. The cost of operating in leased space is approximately $4.3 million per year.

TABLE 1
OTHER SOLAR ENERGY PROGRAMS
PROGRAM ACCOMPLISHMENTS
(Budget Data $ Millions)

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	FY 1978	FY 1979	FY 1980	FY 1981	PROGRAM ORIGINAL OBJECTIVE MET
INTERNATIONAL SOLAR ENERGY PROGRAMS						
TOTAL OBLIGATIONAL AUTHORITY		0	0	0	10.8**	
OBLIGATIONS		0	0	0	10.8**	
o Accelerate the technical development and the market development of five solar technologies, which are included in the U.S. Solar Program, by means of five international cooperative agreements involving about 25 specific projects	o Program support is provided to DOE International Affairs in coordination with the renewable energy technology offices	o Initiated U.S. Saudi Arabia program (SOLERAS) planning for $100 million, 5 year commitment on 50-50 cost sharing basis	o Prepared solar technical plan for the SOLERAS program	o Initiated a 350 kWe solar photovoltaic remote village project o Initiated four solar cooling projects located in southwestern United States	o Completed and tested a stand-alone 350 kWe village photovoltaic power system in Saudi Arabia o Completed installation and initiated testing of 4 solar cooling systems. o Initiated solar desalination and solar controlled agricultrual projects in the U.S. and Saudi Arabia	o Systems operational o Systems Operational o Project initiated
- Undertake 4 bilateral and 1 multilateral agreements covering 25 projects in the five solar technology areas	o Office of Biomass Energy Technology	o Initiated forestry biomass information exchange program	o Established biomass information exchange program activities	o Exchanged information on biomass systems	o Twelve countries exchanged R&D information on forestry biomass energy R&D	o Completed
	o Office of Solar Heat Technology	o Initiated cooperative R&D program in solar heating, cooling and hot water	o Established cooperative solar heating and cooling activities	o Established common procedures for predicting measuring and reporting on solar system performance	o Published a report on U.S., German and Japanese advanced evacuated-tube solar collector systems	o Completed
- Reduce project costs, cooperate in technical advances, and use unique foreign facilities	o Office of Solar Electric Technology	o Initiated design of a 500 kWe distributed collector and a 500 kWe central solar receiver at Almeria, Spain	o Completed design of the two small solar power systems at Almeria	o Began construction of the experimental 500 kWe distributed receiverand 500 kWe central solar power systems	o Completed construction and began operational testing and evaluation	o Construction completed, ready for operational testing

*Funding provided from technology program budgets
**Does not include funding from technology programs

TABLE 1 (Continued)
OTHER SOLAR ENERGY PROGRAMS
PROGRAM ACCOMPLISHMENTS
(Budget Data $ Millions)

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	FY 1978	FY 1979	FY 1980	FY 1981	DOE/OR ORIGINAL OBJECTIVE MET
INTERNATIONAL SOLAR ENERGY PROGRAMS (Continued)						
	• Office of Solar Electric Technology	• Exchanged technical information on wind power and funded studies and workshops	• Conducted workshops on environmental and meteorological aspects of large scale wind systems.	• Obtained technical data for large wind systems used for industrial and electric utility needs	• Analyzed wind flow and the uncertainties associated with various terrain sites	• Completed
	• Office of Solar Electric Technology	• Exchanged technical information on wave power and ocean energy systems	• Initiated a project for testing a wave powered air turbine on Japan's Kamei buoy	• Obtained test data on wave powered machine located at Kamei	• Exchanged test data on wave power machine operated by the United States	• Data exchange
	• Office of Solar Electric Technology	• Initiated U.S.-Spanish agreement for cooperative solar program	• Initiated joint projects for R&D and testing of a 1 MWe solar central receiver system	• Provided DOE technical support on the design and construction of a Spanish 1 MWe solar power system	• Participated in the construction of a 1 MWe solar central receiver power plant in Spain	• Construction completed and operational testing initiated
			• Provided assessment and technical cooperation in applying solar energy to Spain's building energy needs	• Established agreement with Israel for cooperative R&D and information exchange on planner solar collectorsand passive climate control technology.	• Exchanged data on advanced flat-glass optical (luminescent) solar collectors and passive climate controls and instrumentation	• Data exchange initiated
• Assist industry in developing foreign business in solar technology areas by assessing international market conditions and promoting export opportunities for U.S. products and services	• Coordinate activities with DOS, EOC, AID and TDP			• Initiated country market potential and opportunities studies	• Conducted 30 market analyses involving the collection and analysis of overseas market information for dissemination to U.S. industry	• Completed, to be discontinued
				• Sponsored three export management seminars	• Disseminated market analysis information through SERI newsletter, export management seminars, and publications	• Completed, to be discontinued

TABLE 1 (Continued)
OTHER SOLAR ENERGY PROGRAMS
PROGRAM ACCOMPLISHMENTS
(Budget Data $ Millions)

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	FY 1978	FY 1979	FY 1980	FY 1981	DEGREE ORIGINAL OBJECTIVE MET
INTERNATIONAL SOLAR ENERGY PROGRAMS (Continued)						
				o Participated in trade shows and technical seminars in Milan, Italy and Sao Paulo and Florianopolis, Brazil	o Promoted U.S. solar systems through overseas trade shows, seminars Europe and the Far East, and projects designed to use commercial equipment abroad	o Completed, to be discontinued
SOLAR INFORMATION SYSTEMS						
TOTAL OBLIGATIONAL AUTHORITY		3.2	6.4	9.6	9.8	
OBLIGATIONS		3.2	6.2	9.5	9.8	
o Establish and maintain a renewable energy data base and prepare information products based on user needs	o Thirteen Federal agencies provide some form of specialized energy information, e.g., GSA Consumer Information Center and USDA Cooperative Extension Service	o Developed and/or monitored 3 data bases on solar installations, manufacturers and educational programs	o Developed 3 additional data bases including a list of international firms involved in manufacturing solar equipment and components, a calendar of solar events and meterological data	o Maintained 6 solar data bases and updated them to include the latest material.	o Added 3 new data bases and updated existing 6 data bases	o Continuing with emphasis on technical R&D information
o Increase the use of solar energy products, with satisfied clients	o Most State governments have Energy Offices and Extension Services providing information services		o Distributed 50,000 documents on solar energy to the scientific and technical community and consumers.	o Distributed 862,000 documents on solar energy to the scientific and technical community and consumers.	o Distributed 1,700,000 documents on solar energy to the scientific and technical community and consumers.	o On schedule
o Quickly and completely respond to user information requests	o Regional Solar Energy Centers provide solar market and information services	o Answered 179,000 information requests (industry, R&D community and consumers)	o Answered 275,000 information requests (industry, R&D community and consumers)	o Surveyed approximately 1000 clients by telephone to determine user needs and answered 411,000 information requests (industry R&D community and consumers)	Surveyed approximately 50,000 clients by letter to determine user needs and answered 250,000 information request (R&D community and industry)	o Continuing for high priority users

TABLE 1 (Continued)
OTHER SOLAR ENERGY PROGRAMS
PROGRAM ACCOMPLISHMENTS
(Budget Data $ Millions)

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	FY 1978	FY 1979	FY 1980	FY 1981	ACHIEVE ORIGINAL OBJECTIVE MET
SOLAR INFORMATION SYSTEMS (Continued)						
o Sponsor workshops and seminars to disseminate solar information	o Other DOE programs such as Solar Applications for Buildings and information related activities prior to the FY 1981 change in program direction	o During the period between FY 1978 and FY 1980, SERI, SERCIC and the REMCS reached over 20,000 directly people as a result of holding various workshops and conferences for solar trade and professional groups			o Discontinued	o Completed
o Coordinate solar energy information activities of DOE and other Federal agencies in order to eliminate duplication of effort.	o Some private organizations and businesses provide general and/or specialized solar information depending on their overall mission.	o Not applicable	o Not applicable	o Not applicable	o Merged SERI and SERCIC data bases and phased out SERI inquiry and referral service (referral services consolidated at SERCIC) o Completed an inventory of key DOE and other federal agency information activities	o Continuing effort
SOLAR ENERGY RESEARCH INSTITUTE CONSTRUCTION						
TOTAL OBLIGATIONAL AUTHORITY		0	3.0	6.9	9.0	
OBLIGATIONS		0	3.0	6.9	9.0	
o Build a permanent laboratory and office space for approximately 1000 SERI employees that demonstrates economic environmental and aesthetic use of energy conservation and renewable energy technologies by third quarter of FY 1981	o Some - SERI is a unique facility	o Not funded. Initiated permanent SERI facilities planning using SERI and DOE overhead funds	o Initiated work on a conceptual design plan for SERI's permanent facilities which would be 80 percent energy efficient	o Completed conceptual facility design o Completed a revised Title I design which would be 95% energy self-sufficient o Completed Environmental Assessment which indicated no significant impact o Completed Environmental Assessment	o Modified role and mission and developed revised preliminary design plan for laboratory and test facilities	o Design objectives were achieved but facilities were not constructed

TABLE 2
OTHER SOLAR ENERGY PROGRAMS
CURRENT PROGRAM OBJECTIVES AND BUDGET
(Budget data in FY 1982 Dollars: Millions)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS	BUDGET JUSTIFICATION AND SERVICES PROVIDED
INTERNATIONAL SOLAR ENERGY PROGRAM			Enacted BA FY 1982 $4.0 Outyear Projection $9.5
• Accelerate the technical development of five solar technologies, which are included in the U.S. solar program, by means of continuing international cooperative activities under the IEA and U.S./Saudi Arabia (SOLERAS) agreements - Complete 6 projects initiated under the SOLERAS Agreement; obtain operational data on cooperative R&D projects in five solar technology areas currently active in the IEA agreement. Exchange R&D information with 6 foreign countries under existing bilateral and multilateral agreements - Reduce costs in domestic solar program through technical exchanges with solar programs in 5 other countries	• Rely on the private sector to seek international cooperative agreements for technical data exchange and joint projects • Reduce U.S. support to IEA cooperative R&D projects and withdraw from all bilateral joint agreements	• Permit the United States to honor its commitment to the $100 Million 5-year U.S.-Saudi Arabia (SOLERAS) agreement (50-50 cost sharing basis) • Provide for completion of scientific data exchange and joint operational testing of solar and wind systems under existing bilateral agreements with Israel, Mexico and Spain	• Joint SOLERAS testing of four different solar cooling systems in southwestern United States • Experience in the operation of a 250 kWe village photovoltaic power system • Cost sharing in the construction of two large scale solar desalination plants • Cooperative testing of a solar controlled agricultural environment • Operational test data on two 500kWe small solar power systems located at Almeria, Spain; on large wind turbines; forestry biomass energy conversion; and wave power systems • Exchange of scientific data on advanced planar luminescent solar collectors and passive climate control systems (Israel) • Exchange of performance and operational data on solar thermal and wind systems (Mexico and Spain)
• Provide technical assistance in renewable energy technologies to 20 industrial companies interested in international activities 3 government agencies, and 5 foreign countries	• Depend on other government agencies (HUD, DOC, IBCA, TVP, AID) to provide their own technical and economic solar expertise in support of international agreements and cooperative projects.	• Provide for continued DOE technical and economic analyses support to other government agencies and international institutions such as the United Nations and World Bank in the formulation and planning of joint international projects	• Use of unique DOE solar technical expertise to support international commitments and to provide continued technical and economic services to other Federal agencies and financial institutions.

TABLE 2 (Continued)
OTHER SOLAR ENERGY PROGRAMS
CURRENT PROGRAM OBJECTIVES AND BUDGET
(Budget data in FY 1982 Dollars: Millions)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS	BUDGET JUSTIFICATION AND SERVICES PROVIDED
SOLAR INFORMATION SYSTEMS			Enacted BA FY 1982 $6.7 Outyear Projection $33.6
o Prepare high priority information products based on user needs o Quickly and completely respond to client inquiries o Increase the use of solar energy products, with satisfied clients o Coordinate solar and renewable energy information activities within DOE and other Federal agencies	o Rely on private sector to answer inquiries and generate information products o Rely on state and local governments to answer inquiries and generate information products o Rely on other Federal agencies to respond to client inquiries and prepare information products	o Provide for the effective transfer of information produced from research and development to the private sector to encourage renewable energy use on a scale consistent with national goals. (This is consistent with President Reagan's April 20, 1981 memorandum which indicates the public must be accurately informed about Federal programs and activities) o Provide for the maintenance and operation of the present information services which meet the needs of high priority users including the R&D community, the financial sector, equipment manufacturers, architects and engineers o Provide for continued coordination of DOE and other Federal agencies in order to avoid program duplication	o Maintain the capability to respond accurately and timely to telephone and mail inquiries on renewable energy research and development programs (6,000 per week) o Improve the cost effectiveness of information transfer operation through centralized data control and decentralized data inputs o Improve the coordination and integration of solar information activities and articulate DOE policy related to gathering, packaging and dissemination of renewable energy and conservation information o Using the results of user needs surveys produce information products that contain useable and accurate results of Federal Solar R&D programs
SOLAR ENERGY RESEARCH INSTITUTE CONSTRUCTION			Enacted BA FY 1982 $0.0 Outyear Projection $27.5 million
o Build permanent laboratory and office space for approximately 400 SERI employees, that demonstrates economic, environmental and aesthetic use of energy conservation and renewable energy technologies by the fourth quarter of FY 1985	o Continue to use leased facilities	o Complete design and construction of Phase A and Phase B laboratory and test facilities	o Provide for design and construction of 120,000 square foot laboratory/research facility

OCT 7 1981

PROGRAM ANALYSIS UNIT

Program: Alcohol Fuels

Administrator: Director of the Office of Alcohol Fuels

Program Objectives:

The goal of the Office of Alcohol Fuels (AF) is to promote the production, distribution and use of alcohol fuels, thus providing a renewable, domestically produced alternative to imported fuels. AF's mandate is derived from Title II of the Energy Security Act of 1980, PL 96-294. The intent of this act was to reduce the dependence of the United States on imported petroleum and natural gas through the use of economically feasible renewable energy sources that would not impair the nation's ability to produce food and fiber. Prior to the establishment of a separate Office of Alcohol Fuels in February 1980, alcohol fuels activities had been carried on in the Conservation, Fossil Energy, and Solar Energy divisions of DOE. Most of the cellulose-to-alcohol research program had been funded under the DOE Biomass program before being transferred to AF. The Office of Alcohol Fuels now has jurisdiction over all DOE programs dealing with biomass-derived alcohol. Under the authorization of the Energy Security Act, AF will provide loan guarantees to companies using present-day starch or sugar conversion technology. The AF program also focuses on providing high risk R&D on alcohol fuel technology and efficiency not being addressed by commercial enterprises. AF performs these functions under the broad research mandate of the Federal Non-Nuclear Energy Research and Development Act of 1974 (PL 93-577) as well as the Energy Reorganization Act of 1974 (PL 93-483), and the Solar Energy Research, Development and Demonstration Act of 1974 (PL 93-473).

Accomplishments and budgetary authority for the 2-year history of the Office of Alcohol Fuels are included in Table 1. Justification of FY 83 funding is the high level of risk that prevents private enterprises from pursuing necessary R&D in alcohol fuels. These risks and needs include:

- Biomass pretreatment, separation, and by-product utilization economies need improvement to enhance commercial viability.
- Production cost of methanol from biomass is too high for commercial scale.
- Improvements must be made in the utilization efficiency of methanol and ethanol which have fewer Btus than gasoline.
- Cellulose-to-ethanol conversion processes are currently too inefficient and expensive for commercial production.

The financial incentives program will continue to be monitored, but current objectives focus on long-term improvements in process technologies in the following areas:

- o Methanol from wood
  - oxygen gasifier of downdraft design
  - advanced gasifier designs
- o Fermentation alcohols from cellulose
  - pretreatment
  - acid hydrolysis processes
  - enzymatic hydrolysis process
  - separation
  - genetic engineering
- o Utilization technology
  - dissociated alcohol combusion engines
  - multifuel and hybrid engines
- o Support R&D
  - process economics improvements to improve product worth and by-product use.

Section 21 of the Energy Security Act established production and use goals for alcohol fuels of 60,000 barrels per day by the end of 1982 and an amount equal to 10 percent of gasoline consumption 1980. Current production of alcohol used as fuel is 2,800 barrels a year and stimulated by the financial incentives program, is expected to be increasing at a rate that meets or exceeds ESA goals.

The Office of Alcohol Fuels manages all DOE programs dealing with alcohol fuels derived from biomass and reports directly to the Secretary of Energy. The Biomass Energy Systems Program of DOE sponsors R&D in feedstock development and non-alcohol fuels from biomass. The Department of Agriculture makes loans available to small and intermediate sized alcohol producers who qualify for Business and Industry loans under the Farmers Home Administration.

Program Impacts:

Although the Office of Alcohol Fuels has only been in existence a short while, it has demonstrated success in meeting its original objectives. The financial assistance programs (small grants, feasibility studies, cooperative agreements and loan guarantees) have stimulated construction of plants with a production capacity of 1.3 billion gallons of alcohol by 1983. The R&D has had an impact on the advancement of the industry as a result of the following improvements which are leading renewable towards an alcohol fuel industry that can profitably utilize cellulosic materials as its major feedstock. Improvements to date under the R&D program include:

Biotechnology

- Effects on fermentor performance and size of important operation variables such as velocity, product/substrate inhibition, film pore diffusion, etc. for different fermentor configuartions (with and without cell immobilization) have been evaluated. The results have been incorporated into the design of an immobilized cell tubular fermentor.

- Mutants required for isolation of genes for pentose utilization were isolated and successfully transformed by in vitro constructed hybrid plasmids.

Alcohol Synthesis and Utilization

- The mapping of engine performance has been completed for the dissociated methanol system. Results: 35-100% increase in efficiency compared to gasoline (50% typical).

- Completed installation of a dissociated methanol system in the test vehicle (1980 Chevrolet Citation). Road testing was initiated.

- Fifteen atmospheric pressure tests have been completed on the oxygen gasifier using 1/8" and 3/8" wood pellets to determine optimum operation and conditions.

Process R&D

- A fusaruim organism has been identified that hydrolyses and ferments both cellulose and xylose.

- A Clostridia bacteria system has been developed for producing ethanol from corn stover and has been shown to be applicable to (carbohydrate rich) honey locus and mesquite pods.

- Kinetic data has been completed for acid hydrolysis of popular wood.
- A computer model for simulating acid hydrolysis processing is operational. Preliminary sensitivity and parametric analyses are being run.
- A parametric economic analysis model has been constructed and is now being tested.

In addition to the 11 companies already qualifying for financial incentives; the beneficiaries of this program include:

- The driving public who would benefit from the availability of a cost-competitive, reliable renewable, domestically-produced alternative to gasoline,
- Farmers producing feedstocks, alcohol and by-products,
- Municipalities reducing costly disposal expenses and converting waste to alcohol fuel,
- Contractors and manufacturers building factories, chemicals and equipment, and
- Truckers, jobbers, retailers.

In the longer term, R&D on cellulosic conversion will reduce stress on grain and other feedstocks that could be used for food, offsetting any inflation possible in the short term. As technologies become available making alcohol fuels cost-competitive with petroleum-based fuels, competition in industry will increase, and this competition will, in turn, stimulate further production efficiencies. Employment, particularly in lower-skill jobs, will increase in areas where feedstocks and alcohol fuels are produced, especially in the Midwest.

The widespread use of alcohol fuels for transportation should have little effect on health and safety as compared with gasoline use. The Environmental Protection Agency estimates that 100 percent alcohol use in an area could result in a 3 percent increase in ozone but also a 27 percent decrease in carbon monoxide. Other emissions, such as alcohol and aldehydes, are less photoreactive than gasoline emissions and less likely to contribute to smog. When handled with the care appropriate to all flammable and toxic liquids during production and use, alcohol fuels are, on the whole, no more hazardous than gasoline.

Table 2 provides details on current program objectives and summarizes future budgetary requirements.

Projected Program Requirements:

The funding request for FY 83 is $11 million, a decrease from the FY 81 level because of the program's change in focus. This level of effort sustained through the mid-1980s, should provide the technology base for efficient, economically competitive alcohol fuels production and use by focusing on the high-risk, high-payoff areas of R&D.

A ten-percent decrease in the Alcohol Fuels budget would cause a sharp reduction in several promising research areas. Specifically, the wood-to-methanol projects would be reduced by half, delaying until 1986 or later advancements that would substantially reduce the cost of methanol. A funding cut for reseach on acid hydrolysis of cellulose would slow the development of this high-potential ethanol-producing process by at least two years (until 1985). With a ten-percent budget increase, more emphasis can be placed on enzynatic hydrolysis (high and low temperature), advanced separation processes and by-product utilization for ethanol. As a consequence, the technology base for cellulose-to-alcohol processes will be accelerated, and the private sector could utilize cheap, easily available feedstocks to produce alcohol fuels competitively. This R&D will also reduce strains on food crops that large-scale alcohol production might cause at current levels of technology. Advanced engine research could also be augmented to double the effective energy content of alcohol fuels by 1985, a year ahead of schedule.

ALCOHOL ...S
PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS	BUDGET DATA ($ MILLIONS) FY78	FY79	FY80	FY81	Reason Original Objective Not
				22.0	16.0	
To increase domestic alcohol fuel capacity to 920 million gal/year by the end of CY 1982 (P.L. 96-294).						
To accelerate production through financial assistance to manufacturers in the form of funds for feasibility studies and cooperative agreements.				$20.2 for 47 projects. Potential total capacity 1.2 BGPY[1] $34.8 for 2 projects. Actual total capacity 81 BGPY.[2]		
Establish loan guarantee program by promulgating regulations and soliciting for loan applicants (P.L. 96-294).				$274 for 11 projects. Actual total capacity 1.2 BGPY[3]		Program delayed by rescission request.
To encourage technological innovation and technology transfer through providing approximately 200 small grants to small businesses, educational institutions and individuals.				$3.5 for 87 grants.	$1.2 for 27 grants.	
To reduce the cost of ethanol derived from biomass through research and development activities.	Biomass Energy Systems					
-By 1981, examine state-of-the-art in alcohol production technology and develop an R&D plan with cost reduction goals for a mid- and long-range R&D Program.						R&D plan has been developed and is being implemented.

TABLE 1
ALCOHOL FUELS
PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS	BUDGET DATA ($ MILLIONS) FY78	FY79	FY80	FY81	DEGREE ORIGINAL OBJECTIVE MET
				22.0	16.0	
Develop utilization technologies to increase the efficiency possible from alcohol fuels.	Transportation Programs					First generation vehicle has been tested and shows 30% improvement in efficiency.
To provide information to potential producers and users with a capacity to handle 500 phone calls and letters per week.						This objective was exceeded but is no longer viable for out years.

*Prior to existence of OAF 1, 2, 3 ESA 1980 no-year funding not part of R&D budget.

ALC[illegible] FI[illegible]
CURRENT PROGRAM OBJEC[illegible]S AND BUDGET
($ MILLIONS)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS	BUDGET JUSTIFICATION AND SERVICES PROVIDED
To reduce the cost of ethanol derived from biomass to $.75/gal by 1990. -By 1983, identify the optimum pretreatment for each class of cellulosic conversion process for alcohol production. -By 1984, achieve 60% process conversion using acid hydrolysis to allow ethanol to be produced for $1.75/gal. -By 19[illegible] develop a high temperature enzymatic hydrolysis process and a ($.25/gallon credit) use for the lignin by-product and hemicellulose to allow an ethanol cost of $1.50/gallon. By 1984, transfer pressurized oxygen gasifer and catalysis research results to the private sector to allow methanol to be produced for $1.65/gallon.	o Rely on private sector to develop the technology.	o Reduce danger of relying on possible food/feed based fuels. o Extremely low cost raw material. o Increased availability of feedstocks for alcohol. o Assist in alleviating waste disposal problems/ costs.	$m/BO Budget FY82 $10M FY83 $15M o Provide industry with proven processes to initiate large scale production. o Develop efficient enzymes and acids to lower production costs. o Offer potential alternative to land fill dumping. Garbage by ton estimated to contain cellulose.
To develop utilization technologies to increase the efficiency possible from alcohol fuels.	o Provide incentives for manufacturers/individuals to build and use pure alcohol vehicles.	o Avert potential disruption in supply of liquid fuel. o Increased cost of imported petroleum.	o Develop high MPG engines. o Develop possible dual (ethanol & methanol) fuel engines.

95-982 O—82—49

OCT 7 1981

PHASE II

PROGRAM: HYDROPOWER

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

PROGRAM OBJECTIVES:

The Small Hydropower program was begun in 1977 in response to the need to lessen dependence on foreign oil and under the authority of the Nonnuclear Energy Research and Development Act of 1974 (PL 93-577), which authorized R&D with "heavy emphasis" on renewable technologies. At that time, the small hydro industry was in a dormant state because of its inability to compete with low-cost oil and large central station thermal plants. In 1978, the Public Utility Regulatory Policies Act, known as PURPA, (PL 95-617) authorized loans for feasibility studies, licensing and construction costs for small hydro projects.

Because hydropower technology is mature, the program strategy has been for the Federal government to "step in," help reawaken the industry by mitigating technical, legal, institutional and environmental barriers particularly associated with small hydro, and then to "step out" leaving development to non-Federal sectors. Demonstrations and loans have been used to stimulate near-term developer activity, but rising costs of energy alternatives were expected to be the stimulus for continued development.

The basic historic goal has been to reestablish a vigorous small hydro industry in the U.S. Supporting objectives included: (1) to demonstrate the current commercial feasibility of small hydropower; (2) to provide loans to encourage developers by assisting with preconstruction costs; (3) to directly assist 1,000 MW on-line or under construction by 1985 through the demonstration and loan programs; (4) to reduce the costs of small hydro development through R&D on (a) new techniques for retrofitting existing sites and ultra low-head sites, and (b) environmental barriers; (5) to mitigate and help states mitigate legal, institutional and technical barriers; and (6) to develop and disseminate technical information to interested developers. Further specifics are provided in Table 1.

Several other Federal agencies have programs impacting on small hydro development, e.g., Federal Energy Regulation Commission, Corps of Engineers, Bureau of Reclamation. None exactly duplicates the DOE program nor shares the basic objective of encouraging non-Federal development.

Alternative methods for improving hydropower development might include direct Federal construction programs (contrary to Administration policy), or expanded tax and financial incentives.

PROGRAM IMPACTS:

The basic DOE goal has largely been met, as evidenced by FERC permit applications which have increased dramatically since the small hydro program was initiated. FERC staff estimate that 1,900 applications will

be received in 1981, compared to 600 for 1980 and a total of 130 for the previous 4 years. Interim objectives of the demonstration program have also been met, with five projects totaling 11 MW on-line and ten others underway, all serving as useful test cases of development barriers. The five remaining projects are still in the licensing stage. Funding has been provided for the full Federal share of all 20 projects, which will bring 133 MW of small hydroelectric generating capacity on-line by 1985.

The loan program was operational for less than 1 year, but it helped stimulate considerable developer interest, particularly by municipalities and other nonprofit entities. It is too early to determine how many loan-assisted projects will make it to the construction phase in the near future. The biggest portion of the 1,000 MW objective for power on-line or under construction by 1985 would have been achieved through the loan program. However, only the 133 MW provided by the demonstration projects are directly supported.

The principal beneficiaries that have received financial assistance under the program through FY 1981 have been the 20 demonstration project developers and the approximately 225 developers who received support for feasibility studies. In addition, all developers will benefit from the resource assessments assisted by DOE funding. Grants have been provided to a total of 40 states for a variety of purposes, including resource assessments, developer workshops, and institutional reforms.

Technical assistance has also been provided to 24 state legislatures and 16 public utility commissions. Dozens of technical reports on generic and state-specific problems have been provided to assist developers, the states, and FERC. Further details are given in Table 1.

The current and potential small hydro contribution to the national economy is small but still significant. For example, FERC estimates that by 1995 up to 20,000 jobs and $300 million of electric energy will be created annually through small hydro development. The DOE program has helped to improve the relative competitive position of small hydro and enlarge the number of individual developers. Hydropower provides a significant portion of energy needs in some regions, together with improved economic stability, immunity to inflation and lower life-cycle costs for users.

Overall, the development and redevelopment of small hydropower projects will not have a significant effect on the quality of the human environment. There may be significant localized impacts of both a positive and negative nature from some projects. Adverse effects may result from increased turbidity and release of toxic substances during construction and possible release of toxic substances or poor water quality during operation. Other possible adverse effects involve fish passage around the dam, both upstream and downstream; reservoir water level fluctuations where used for seasonal drawdown or daily store-and-release operation; and water quality deterioration or changes in dissolved oxygen, temperature, and chemical nature. Areas for possible tradeoffs among land and water uses include minimum instream flow needs downstream from the reservoir, and river basin-wide management of both power and aesthetic values.

Environmental and health aspects of small hydro as well as mitigation measures are evaluated in a series of Oak Ridge National Laboratory (ORNL) Technical Manuals, entitled "Analysis of Environmental Issues Related to Small-Scale Hydroelectric Development (I through VIII)," initiated and funded under the small hydro program. The safety aspects of all hydro, both large and small are the responsibility of the Corps of Engineers. Since the recent dam failures in Idaho and Georgia, the Corps has been very active in improving dam safety throughout the Nation. In fact, several of the hydro retrofit developments now underway are the result of the Corps' requirement to either breach or upgrade particular structures. In general, their dam safety improvement is a concurrent aspect of small hydro redevelopment.

The Department believes that overall administration of the small hydro loan program has been effective in meeting program goals and objectives and carrying out Congressional intent. This intent was to stimulate interest and help developers with front-end financing for feasibility studies and licensing costs for high-risk ventures that involve many unknowns during early stages. The program's success is evidenced by the number of such developers who have been assisted. There is no way, however, to identify the number of such developers who would not have undertaken studies or licensing procedures, but for the loan program.

PROJECTED PROGRAM REQUIREMENTS:

No funds have been requested for FY 1983 or beyond for the DOE Hydropower program. The 20 demonstration projects are fully funded although there should be some monitoring, evaluation and technology transfer activities associated with these projects. Monitoring of the feasibility study and licensing loans will also be necessary. The staff and funding required for these activities will be provided under general support activities, and largely implemented by the Idaho Operations Office.

DISCONTINUATION REQUIREMENTS:

The 20 demonstration projects (fully funded) will require a minimum of $100 K per year to continue monitoring and evaluation through FY 1985, with staffing support (averaging 1 man year per year) provided by ID. Another $100 K per year, and possibly some support by HQ and/or other field offices, would be required for good technology transfer of the "lessons learned" to developers, state agencies, etc.

Most of the loan program activity related to the 170 DOE loan awards will have been completed by the end of FY 82. There will be decreasing monitoring and "clean-up" actions by ID for several years, but these should not require any special funding or staffing. Under the Public Utility Regulatory Policies Act of 1978, DOE must cancel loans if projects are determined not feasible.

It is also expected that R&D contracts will be closed out by the end of FY 1982, and that no special funding or staffing would be required in the following years. Information dissemination activities, to the extent

they are undertaken, could be treated the same as for the demonstration projects. There is a possibility that the Congress may appropriate $3 million for environmental and other R&D projects for FY 1982 which the Administration did not request. There would be little additional impact in FY 1983 if these funds are utilized for this purpose, provided that the contracts involved are initiated in the first half of the fiscal year.

There will also be a continuing headquarters' requirement to address policy issues on hydropower, such as in Congressional mail, as well as to provide guidance for activities conducted in field offices.

Alternative locations for DOE hydropower responsibilities could be with the Federal Energy Regulatory Commission, Interior, the Corps of Engineers, and Agriculture. Interior and the Corps have the technical competence to handle these activities, although they would have to broaden their traditional roles to encompass non-Federal development issues. FERC is also competent to assume the DOE functions, although it is a regulatory agency. Agriculture (the Rural Electrification Administration) also has considerable expertise in this field, although it has dealt with a rather narrow clientele group.

Table 1

Hydropower

Program Accomplishments

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ Thousands)				DEGREE ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
	Total Oblig. Auth.	$11,000	$19,000*	$27,000*	$11,800*	
	Obligations	9,215	16,197	10,671	11,932	
1. Demonstrate the commercial feasibility of small hydropower - 5 projects and 11 MW by January 1982 - 11 projects and 40 MW by January 1983 - 16 projects and 87 MW by January 1984 - 30 projects and 133 MW by 1985.	None	Selected one pilot demonstration project (Idaho Falls).	Selected remaining projects, with an aver. of 15% Federal cost-sharing by: municipalities (7), utilities (6), irrigation districts (3) industry (2) and other developers.	Initiated monitoring; first 2 projects on-line; considerable attention by industry and the public; minimum flow issue uncovered.	Total of 5 projects and 11 MW on-line; completed funding for all projects; began disseminating "lessons learned."	Interim objectives have been met; on-schedule to complete objectives of commercial power-on-line by 1985 and monitoring/dissemination of lessons learned by 1987.
2. Provide loans for feasibility studies and licensing costs. - Use to stimulate developers. - DOE processing time of 90 days or less. - awarded 575 loans, leading to projects totaling 670 MW.	HUDA/ REA loans		Loan regulations developed.	Loan program initiated, using decentralized field offices; 86 loans approved.	A total of 188 loans approved, with aver. processing time less than 90 days.	Program was terminated in March 1981. It helped generate considerable activity, particularly by nonprofit entities but power-on-line goal is doubtful due to suspension/reduction of loan program.
3. Provide technical assistance to bring additional projects on-line or under construction by 1985 (total of objectives 1, 2 and 3 to provide 1,000 MW).	None				Technical assistance provided by DOE regional offices to stimulate most viable projects.	Original objective may not be met due to suspension/ reduction of regional activities.
4. Reduce the cost of small hydro development through R&D on - New techniques for retrofitting sites and for ultra low-head sites. - Generic envir. barriers.	None	Began resource and envir. assessments; awarded 54 feasibility study grants.	Began ultra low-head (ULH) R&D and generic envir. studies; issued feasib. study manual.	First ULH model lab tested; continued other projects; initiated paper eng. on min. streamflow issue.	Four more ULH studies completed; began pumps-as-turbines exper. profile; began o.m. field tests.	First ULH device (Schneider) installed in 2 locations; 4 of 7 envir. manuals in print, final design manual waiting at rate of several dozen per month.
5. Mitigate and help states mitigate legal, institutional, technical barriers.	None		Initiated contracts to identify state legal and institutional barriers, and grant to NCSL to assist state legislatures.	Initiated grants to states and tech. assistance to PUC's for implementing PURPA incentives.	Grants provided to total of 40 states for resource assess., inst. reforms, etc; tech asst. provided to 20 legislatures and 16 PUC's; 36 state-specific and 3 generic studies published.	More than 10 states have approved legislative reforms; most states have met initial PURPA requir; substantial state permitting barriers remain.

* Reflects the results of the FY 1981 Rescission.

OCT 7 1981

CE/DGHT - Input to Volume II of DOE, Title X Sunset Review

PHASE II - Draft PAU October 6, 1981

PROGRAM: GEOTHERMAL RESOURCES

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

PROGRAM OBJECTIVES

Hydrothermal, geopressured and hot dry rock are the three principal types of geothermal resources (in order of technological readiness) which can supply large amounts of energy for electric power production and direct heat applications.

The historical goal of the DOE program has been to increase the use of geothermal energy resources as reliable, operationally safe, environmentally acceptable, and economically viable alternative energy sources for electric power generation and direct heat applications. Through FY 1981, the program emphasized the reduction of resource uncertainties and removal of the technological, economic and institutional impediments inhibiting the commercial development of geothermal resources. The program objectives addressed risks perceived by the private sector in the area of reservoir capacity and longevity, the high cost of field development, commercial scale plant economics, environmental effects of production, and unproven energy extraction and conversion technologies. The program objectives pursued between the FY 1978 and FY 1981 time period are shown in Table 1.

The current program concentrates on high risk, high payoff R&D work with reduced emphasis on short-term R&D and a phaseout of hydrothermal industrialization activities. The goal is to develop those elements of high payoff advanced geothermal technologies that the private sector is currently unable

or unwilling to undertake but which are required for commercial development of the nation's extensive geothermal resources. The major objectives and needs to be met are listed in Table 2.

One viable alternative means of achieving the objectives of the current program would be to provide tax credits to industries capable of performing advanced geothermal R&D. Another alternative would be to rely on the private sector to develop and exploit geothermal resources at a pace determined entirely by the dynamics of the market place. The target dates would then slip by approximately five years.

The Geothermal Energy Research, Development and, Demonstration Act of 1974 (Public Law 93-410) established the Geothermal Energy Coordination and Management Project (now called the Interagency Geothermal Coordinating Council) and directed the Project to develop and report a coordinated Federal program to the Congress. The Program Definition Report (ERDA-86) was submitted and published in October 1977. The program directed by Congress included demonstration plants, loan guaranties, and extensive lists of necessary R&D activities to be undertaken. The wide range of functions and activities named in Public Law 93-410 were amended and/or expanded in Public Law 93-438, Public Law 93-577, Public Law 95-91 (Section 102 and 203), Public Law 95-238 (Section 101, 501-512), and Public Law 96-294 (Title VI).

The Interagency Geothermal Coordinating Council (IGCC), chaired by the Assistant Secretary for Conservation and Renewable Energy in DOE, monitors and coordinates the program activities of eight Federal agencies having responsibilities for various aspects of geothermal development. The IGCC has been successful in identifying alternative policy options, streamlining administrative procedures and alleviating potential duplicative R&D efforts in the Federal Geothermal Program.

The geothermal industry is presently composed of a relatively small number of corporations - the most significant of which are the energy companies and utilities. Although the resource is large, the current market for geothermal energy is perceived to be small by these industries. Advanced technology R&D required to expand the economically exploitable resource base involves high risk, long term ventures that are presently unattractive to most companies. The geothermal program is designed to increase the commercial development of geothermal resources by conducting the high-risk/high payoff technology development that the geothermal industry is unable or unwilling to undertake but which is required to exploit the nation's extensive geothermal resources.

Table 2 outline the current program objectives and budgets for FY 1982 and FY 1983. The major thrusts of the program are to conduct R&D directed toward reducing the costs of field development, cost of electric generating facilities, as well as the risks in all aspects of fluid handling associated with the use of high and moderate temperature hydrothermal resources; and determining of the technical and economic feasibility of extracting energy from geopressured and hot dry rock resources.

PROGRAM IMPACT:

The geothermal program has benefited the national economy by providing a reliable, domestic supply of energy for small, mostly rural communities; contributing competitively to electric baseload requirements in the western U.S.; reducing risk for small companies through support of R&D; and creating jobs in local communities. Beneficiaries of the program have included several

hundred manufacturers, industrial/commercial park managers and users in 37 states; more than 100 cities, towns or rural areas serving 1 million consumers; 65 energy companies and industrial firms, more than 200 public and private building managers in 20 states; and state energy offices in 16 states.

These impacts have been achieved because the geothermal program has significantly reduced the risk of finding suitable geothermal resources, reduced the cost and uncertainty of using geothermal resources, significantly increase the size of the economically exploitable resource base and stimulated the now rapidly increasing non-electric geothermal industry.

Geothermal resources have been identified in 37 states with promising hydrothermal reservoirs (hot water and steam trapped in relatively near surface rocks) of high-and moderate-temperature being defined in the western U.S. and new areas of promise for low- to moderate-temperature hydrothermal resources being identified in the East. Reservoirs confirmed are sufficient to allow private industry to meet the IGCC goal of 3000 MWe of electric capacity by 1985. Electricity is being generated at the Geysers steam field and in the Imperial Valley California. The economic production of power from hot water reservoirs is expected in several western states in the near future. Maintaining the desired pace of hydrothermal electric power development through the year 2000 will require the confirmation of new reservoirs in the 1980's by private industry as well as the continued DOE support of the development of technology to reduce the cost of producing electricity from moderate temperature (150°C-180°C) reservoir fluids.

The reduced cost and risk of using geothermal energy and the increased size of the economically exploitable resource base were accomplished by the drilling, energy conversion, and environmental control technology and materials research program. Successful tests of improved drills bits, downhole motors, improved drilling fluids, and well completion equipment and techniques have provided confidence that by 1983, improved technology will be available to meet the objective of a 25 percent reduction in drilling cost. The energy conversion R&D has been directed toward reducing geothermal electric power generating costs, particularly for moderate-temperature resources which are more prevalent but more expensive to develop than high-tempeature resources. Successful tests of improved drill bits, downhole motors, improved drilling fluids, and well completion equipment and techniques have provided confidence that by 1983, improved technology will be available to meet the objective of a 25 percent reduction in drilling cost. The energy conversion R&D has been directed toward reducing geothermal electric power generating costs, particularly for moderate-temperature resources which are more prevalent but more expensive to develop than high-temperature resources. Successful testing of three small-scale binary cycle power systems employing direct contact heat exchangers suggests that a 20 percent reduction in capital costs for electric generating facilities may be achievable by 1987. In response to the need to keep environmental effects within acceptable limits at reasonable costs, a pilot scale H_2S removal process for geothermal steam was successfully tested at the Geysers, CA., and a major utility announced plans to build a full-scale plant. The projected effect of R&D technology improvements on the cost of geothermal electric power is to significantly increase the amount of

resource tht is economically competitive as shown in Figure 1. It is estimated that the R&D efforts through FY 1981 have achieved an average electric busbar cost reduction of 7 percent for high temperature (>150°C) resources from a base of 40 mills/kWh and 10 percent for moderate (150°C-180°C) resources from a base of 120 mills/kWh.

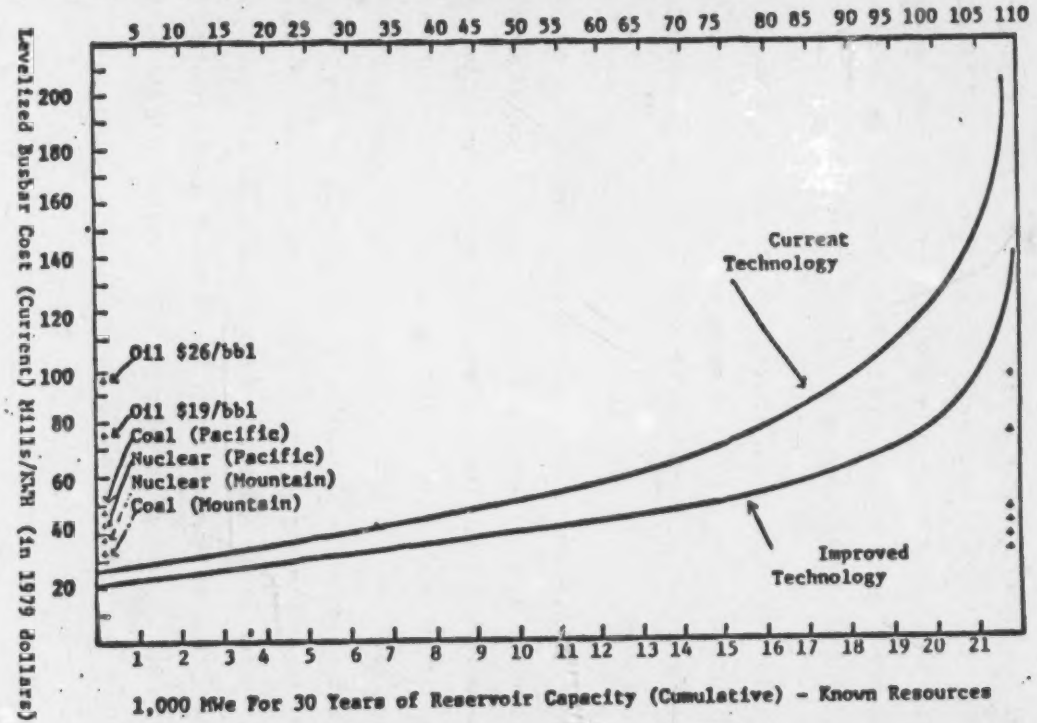
The risk and cost of using hydrothermal resource for electric power production were greatly reduced by the construction and operation of a 5 MWe pilot plant in Raft River, Idaho, a 3 MWe geothermal wellhead generator system in Hawaii, and the design and construction of a commercial-scale (50 MWe) flash-steam demonstration plant at Baca Ranch, New Mexico. For example, utility companies have publicly announced their intentions to build hydrothermal electric generating plants using hot water reservoirs to produce generating capacity totalling more than 1,000 megawatts electric.

The technology for direct use of hydrothermal energy for space heating and process heat is well developed and economical. The completion of 50 technical and economic studies of direct heat applications designed to match the energy needs of prospective users with specific low to moderate temperature resources and the initiation of 23 cost-shared direct heat demonstration projects to provide visible evidence of the profitability of various applications have stimulated independent industrial activity. By the end of 1980, 211 direct use developments in 14 states were providing 12,647 billion Btu's annually. By the end of 1981, it is anticipated that another 29 projects will be supplying an additional 5.582 billion Btu's annually. Over 100 of these viable geothermal projects for direct heat use have been aided during the past two years through DOE support of state development planning projects.

Figure 1

COST CURVES FOR GEOTHERMAL (HYDROTHERMAL) ELECTRICITY

1,000 MWe For 30 Years of Reservoir Capacity (Cumulative) - Known & Inferred Resources*


5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110
Levelized Busbar Cost (Current) Mills/KWH (in 1979 dollars)
200
180
160
140
120
100
80
60
40
20
Oil $26/bbl
Oil $19/bbl
Coal (Pacific)
Nuclear (Pacific)
Nuclear (Mountain)
Coal (Mountain)
Current Technology
Improved Technology
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
1,000 MWe For 30 Years of Reservoir Capacity (Cumulative) - Known Resources

* Does not include The Geysers. Upper horizontal axis assumes inferred sites to come in at cost of and in proportion to discovered sites. (Based on USGS estimates).

To facilitate the flow of capital into the high risk geothemal industry, a geothermal loan guaranty program was established. Six loans (including one refinancing) totalling $136.0 million for projects totalling $202.7 million in cost have been guarantied. Four of these projects will provide an added 258 MWe to current electric power production, and the other project is providing 117 billion BTU/year for food processing.

Uncertainty about the size, characteristics and potential use of the very large geopressured and hot dry rock resources have been greatly reduced. However, the technical and economical feasibility of energy extraction has not yet been proven.

Geopressured resources are hot water aquifers containing dissolved methane trapped under high pressure in deep sedimentary formations located along the Texas and Louisiana Gulf Coast. The initial resource definition effort has defined geopressured fairways in Texas and candidate geopressured prospects in Louisiana. To date, short term testing of resource characteristics has been completed for 15 existing oil and gas wells and long-term testing of reservoir characteristics is under way for four specially designed production wells. By the end of 1982 geologic studies and well testing will have produced detailed reservoir data. The results of these production tests and critical R&D projects will provide the initial insight into the technical feasibility of developing geopressured resources.

Hot dry rock resources are geologic formations at accessible depths that have abnormally high heat content but contain little or no water. Usable energy is extracted by circulating a heat transfer fluid, such as water, through deep wells connected by man-made fractures in rocks. In early FY 1978 a 5 megawatt thermal loop created by hydraulic fracturing in deep wells was operated on an experimental basis at the Fenton Hill hot dry rock resource site in New Mexico. The second experimental phase of the hot dry rock (HDR) energy extraction project was initiated in FY 1980 with the completion of the first well of a large (20-50 MWt) hot dry rock thermal loop; the second well was completed in FY 1981. Development of the underground heat transfer system will be initiated in mid-FY 1982 with a series of fracturing experiments to be followed by surface system construction. The system will be near-commercial in configuration and, as such, will provide critically needed data on reservoir lifetime and operating characteristics.

Details of program accomplishments and corresponding budget data for Fiscal Year 1978 through 1981 are presented in Table 1.

Potential environmental problems affecting electric power generation include release of airborne effluents, particularly H_2S; disposal of large volumes of spent geothermal fluids with varying amounts of dissolved solids; high noise during drilling and field operation; possible subsidence due to large volume fluid withdrawals; possible induced seismicity associated with fluid withdrawal or reinjection; requirements for cooling water; and land use conflicts. Airborne emissions and possible water use conflicts are believed to be the principal problem areas but technology currently in final commercial scale development appears capable of meeting air quality standards for H_2S,

and water use conflicts will have to be addressed on a site-by-site basis. None of the other potential environmental impacts are expected to seriously impede resource development. In general, the environmental impacts of non-electric uses are the most benign as fluids are lower in temperature and tend to contain fewer dissolved solids.

The geothermal program has produced a positive effect on the Nation's health and safety by performing geothermal R&D for expanded use of environmentally benign energy sources. Geothermal technology has been proven to be relatively safe and is not known to present any insurmountable health problems. The DOE program has included R&D in environmental control technology and field activities designed to monitor and mitigate possible adverse impacts of program activities associated with the development of hydrothermal, geopressured and hot dry rock resources.

The funding request for FY 1982 is $48.375 million, appreciably below prior year levels because of the change in program focus. The funding request for FY 1983 is $42,000 million. This level, if sustained through the mid-1980's, will provide a sound base for hydrothermal resource development, permit evaluation of extent and magnitude of the economically recoverable geopressured resources, and determine the technical and economic feasibility of exploiting the potentially very large hot dry rock resources by 1990.

A 10 percent increase in the level of support will accelerate the development of advanced binary cycle power technology thereby permitting the demonstration of the economic viability of moderate-temperature resources two years ahead

of schedule (from 1987 to 1985). If funding levels were decreased by 10 percent, decision points for technical assessment of the viability of geopressured and hot dry rock resource development would be delayed by one year (from 1986 to 1987 and 1990 to 1991, respectively).

DISCONTINUATION REQUIREMENTS

Undue disruption because of discontinuation of the program, could be ameliorated by a gradual phase-out of selected program elements, especially in cases where projects are nearing completion or are being conducted under current contracts relating to international agreements. Geothermal R&D at DOE National laboratories could be phased-out over a two-year period; the contract with industry for the construction and operation of the 50 MWe demonstration power plant at Baca, NM could be terminated in FY 1983 although with loss of operational data; and $10 million annually would have to be provided through FY 1984 in order to honor the agreements for cost-shared, cooperative hot dry rock experiments with the Republic of Germany and Japan. Finally, authorizing legislation needs to be amended to cover the termination of the Geothermal Loan Guaranty Program in FY 1982.

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TABLE 1

GEOTHERMAL

PROGRAM ACCOMPLISHMENTS

GOAL/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ Millions) STATUS FY 78	FY 79	FY 80	FY 81	DECREE ORIGINAL OBJECTIVE MET
	T.O.A.	$ 107.1	$ 152.3	$ 150.4	$ 139.1	
	O	105.0	151.1	148.8	139.1	
HYDROTHERMAL RESOURCES						
• Confirm the existence and commercial potential of reservoirs suitable for electric power generation and/or direct heat applications to meet ICCC goals	• None	• Reservoir confirmation drilling initiated with major developers; resources identified in 37 states	• 3 exploratory wells drilled; 3 state maps published	• 9 deep exploratory wells drilled; assessment activities in 28 states	• 53 reservoirs identified for 23,383 MWe; assessment activities in 34 states; 6 state resource maps published; 15 in preparation	• Reservoir confirmation activity sufficient to meet ICCC goal of 3,000 MWe of electric capacity by 1985; new reservoirs needed to reach goal for year 2000
		• 59 deep wells drilled by private industry	• 75 deep wells drilled	• 68 deep wells drilled	• 70 deep wells drilled	• Sufficient reservoirs have been identified to meet direct heat applications goals through 1983
• Reduce field development costs and capital costs electric generating facilities to achieve by 1987 an average busbar cost reduction of 10 percent for high temperature (>180°C) resources and 30 percent for moderate temperature (150°C-180°C) resources	• None	• Improved drilling bits; direct contact heat exchanger; H_2S control system	• Improved drilling technology. 100 kWe and 500 kWe power systems; 5 MWe gravity-head binary system; descaling technique	• Inert gas drilling, 500 kWe binary system test; 3 reservoir stimulation experiments	• High temperature drilling mud; cements and logging tool; power plant control system; binary system field test	• Technology development is on schedule; average electric busbar cost reduction of 7 and 10% achieved for high and moderate temp. resources, resp.
		• Reduction in electric busbar cost: High temp.-1% Mod. temp.-2%	• High temp.-1% Mod. temp.-2%	• High temp.-1% Mod. temp.-2%	• High temp.-3% Mod. temp.-4%	• Results adopted by industry and incorporated into designs for electric power systems
						• Major improvements achieved in drilling bits, direct contact heat exchangers, low-cost materials, descaling techniques, environmental control system

TABLE I

GEOTHERMAL

PROGRAM ACCOMPLISHMENTS

GOAL/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ Millions) STATUS				DEGREE ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
		$ 107.9	$ 151.0	$ 150.4	$ 137.5	
• Demonstrate the technical feasibility and economic viability of (i) electric power systems for high temperature resources by 1983 and for moderate temperature by 1986 and (ii) direct heat applications for low to moderate temperature resources by 1982	• 10 MWe pilot plants by private sector at East Mesa and Niland, CA	• 5MWe pilot plant-construction began (IB)	• Construction continued	• Construction completed	• Plant start-up and operation	• Demonstrated 1-3MWe wellhead generator systems; flash-steam demonstration under construction; Binary demonstration not completed
		• 50 MWe flash-steam plant-contractor selected (NE)	• Agreement signed with industry	• Plant design underway-well drilling started	• Construction started; Binary cycle plant design started	
		• 3 MWe wellhead generator system-construction began (NI)	• Construction continued	• Construction continued	• Construction completed; system start up; plant dedicated	• 12 of 23 direct heat applications successfully demonstrated
		• 1 MWe helical screw expander tested (UT)	• System refurbished for test at foreign sites	• 34 direct heat applications studies completed-8 new studies	• 8 direct heat studies completed	• More electric power plants will be built by 1985 by industry than originally estimated
		• 8 direct heat demonstration projects started	• 15 new projects initiated; reservoirs confirmed at 7 sites	• 6 direct heat projects became operational	• 6 additional projects became operational	
• Alleviate legal and institutional barriers to geothermal development	• None	• National Conference of State Legislatures (NCSL) project initiated to expedite modification of state laws affecting geothermal development	• NCSL provided research and legal assistance to 6 state; Institutional Barriers Report issued	• NCSL services extended to 8 additional states; total of 38 bills considered in 12 of 14 states	• NCSL effort extended to states in eastern U.S.; Federal buildings program; reservoir insurance study	• State laws changed or under active consideration in one third of states with geothermal resources; state and Federal procedures still need streamlining

TABLE

GEOTHERMAL

PROGRAM ACCOMPLISHMENTS

GOAL/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ Millions) STATUS				DEGREE ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
		$ 107.9	$ 151.0	$ 150.4	$ 137.5	
• Provide technical assistance to potential geothermal users; maintain technology base and transfer results to the private sector		• 3 operations research projects initiated	• State development planning teams initiated in 10 western states • Technical assistance center established at Idaho Falls, ID covering 10 state region	• 6 additional state planning team efforts initiated including 1 in East • Technical assistance centers established in Maryland, Utah, and Oregon	• State development plans issued by 16 western states; over 100 viable direct heat projects facilitate • 5 technology components transfered to industry	• Assistance was provided as requested by potential direct heat users • Several hundred R&D reports distributed; technology transfer on schedule
• Coordinate and monitor the Geothermal programs of all Federal agencies	• None	• 2nd Annual IGCC Report to Congress published	• 3rd Annual IGCC Report to Congress • IGCC Streamlining Task Force Report • Completed design of Geothermal Progress Monitor system; pre-lim report issued	• 4th Annual IGCC Report to Congress • 14 recommendations of Streamling Task Force incorporated in legislation by Congress • Geothermal Progress Monitoring System established; 3 reports issued • IGCC Environmental Control R&D Panel Report issued	• 5th Annual IGCC Report to Congress • Market penetration analyses for hydrothermal resources completed • Geothermal Progress Monitor Report issued	• A system to monitor geothermal progress has been established and is up-to-date • All IGCC reports issued as required

TABLE I

GEOTHERMAL

PROGRAM ACCOMPLISHMENTS

GOAL/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ Millions) STATUS				DEGREE ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
		$ 107.9	$ 151.0	$ 150.4	$ 137.5	
• Reduce front-end risks in exploring for and developing hydrothermal reservoirs by authorizing guaranteed loans through 1985	• None	• 12 applications received for guaranteed loans	• 13 applications in preparation; estimated value of $42.9 million	• 15 loan guaranty loan applications in preparation, estimated value of $556 million	• Applications pending for loan guaranties totalling $284.5 million	• Of the $500 million authorized loan guaranty limit, $136 million were used
		• 2 loans guaranteed; totalling $4.6 million	• 2 loans guaranteed; totalling $30.8 million; 4 projects pending	• 2 projects approved for guaranties of $94.4 million	• Processing of loan guaranties suspended March 1981 due to policy change	
GEOPRESSURED RESOURCES						
• Define the extent and magnitude of the geopressured resource and determine the engineering and economic feasibility of recovering the associated methane, heat and hydraulic energy by 1986	• None	• Resource assessments identified for 63 candidate reservoirs in TX & LA	• Definition studies produced maps of resources in TX & LA	• Arrangements made for short term testing of 4 wells-of-opportunity	• 12 oil/gas wells re-entered to date for short-term testing	• The program is on schedule and about 50% of the necessary re-entered oil/gas wells and long term test wells have been or are being evaluated.
		• Drilling of first test geopressured well in Brazoria County, TX	• Brazoria test well completed and made ready for long term testing	• Initial testing began with Brazoria well; high flow rate 40,000 bb/day	• Long term testing of Brazoria well continued; 4 new test wells drilled	
HOT DRY ROCK RESOURCES						
• Demonstrate the technical and economic feasibility of extracting energy from hot dry rock resources by 1990	• None	• 5 MWt hot dry rock energy extraction loop successfully operated at Fenton Hill, NM	• Drilling initiated for 1st well of 20-50 MWt loop at Fenton Hill	• 1st well of thermal loop (20-50 MWt) completed; work on 2nd well started	• 2nd well of HDR thermal loop completed	• Phase I: 5 MWt pilot HDR system successfully operated
			• IEA Agreement signed by Federal Republic of Germany for FRG participation in HDR project	• Site selection analyses for second experimental site began	• Completed IEA agreement with Japan to share cost of experimental work at Fenton Hill	• Phase II: near-commercial (20-50 MWt) system being installed on schedule
						• Second site not yet selected

GEOTHERMAL

CURRENT PROGRAM OBJECTIVES & BUDGET

(Budget data in FY 82 dollars; millions)

Goals/Objectives	Alternative Methods	Anticipated Needs for Objectives (Target Date)	Budget Justification & Services Provided
1. Hydrothermal Resources			
a. Reduce field development costs and capital costs of electric generating facilities sufficiently to achieve by 1987 an average busbar cost reduction of 10 percent for high temperature (>180°C) resources and 30 percent for moderate temperature (150°C-180°C)	• Provide tax credits for industries that perform hydrothermal technology research and development.	• Improved drilling and completion equipment to reduce costs 25 percent (by 1983) • Advanced reservoir stimulation techniques (by 1985) • Improved exploration technology and reservoir engineering techniques (by 1985) • Advanced energy conversion systems for moderate temperature resources (by 1987) • Improved materials for geothermal fluid handling systems (by 1985) • Advanced pollutant control technology (by 1983)	Budget FY82 $10.4 FY83 $15.0 Estimated Outyear Costs $60.0 • Improved drilling technology • Adaptation of seismic imaging techniques to geothermal exploration • Improved well stimulation technology • Direct contact heat exchanger technology • Advanced binary power systems
b. Establish technical and economic viability of electric power generation from liquid-dominated by resources by 1985	• Reliance on private enterprise	• Cost-share construction of 50 MWe flash-steam plant (to be completed in 1983) • Operational test of 5 MWe pilot binary cycle plant (by 1982)	Budget FY82 $6.0 FY83 $7.2 Estimated Outyear Costs $0 • Complete construction of 50 MWe plant • Complete operational test of 5 MWe plant

Goals/Objectives	Alternative Methods	Anticipated Needs for Objectives (Target Date)	Budget Justification & Services Provided
c. Transfer technology to private sector	• Reliance on private sector	• National Laboratories develop and maintain data bases and transfer technologies (continuing)	Budget FY82 $.5 FY83 $.5 Estimated Outyear Costs $2.0 • Results of DOE research and development disseminated to private sector
d. Monitor existing projects with guaranteed loans		• Review of guaranty loan projects and monitoring of loan repayment activity	Budget FY82 $.2 FY83 $.2 Estimated Outyear Costs $0 • Monitor existing loan projects only

e. Coordinate and monitor all Federal geothermal activities		• Interagency Geothermal Coordinating Council (IGCC) (Annual and ad hoc meetings) • IGCC Staff Committee, panels, and working groups (periodic meetings) • Geothermal Progress Monitor System (quarterly reports) and IGCC Annual Report	Budget FY82 $0 FY83 $0 Estimated Outyear Costs $0 • IGCC activities supported by DOE staff
2. Geopressure Resources			
a. Define geopressured resource by 1984 and determine feasibility of energy recovery by 1986	• Provide tax credits for private sector resource • Reliance on private sector	• Complete long-term testing of design wells (by 1983) • Short term testing of wells-of opportunity (by 1983) • Complete evaluation of reservoir data (by 1984)	Budget FY82 $20.3 FY83 $ 5.0 Estimated Outyear Costs $30.0 • Dissemination to industry of information on extent of resource and economics of energy recovery
3. Hot Dry Rock Resources			
a. Determine technical and economic feasibility of extracting energy from hot dry rock resources by 1990	• Provide increased tax credits for private sector R&D • Reliance on private sector	• Commercial size energy extraction facility at Fenton Hill (by 1983) • Pilot size energy extraction facility at second hot dry rock site (by 1985)	Budget FY82 $13.0 FY83 $ 9.0 Estimated Outyear Costs $100.0 • Complete 20-30 MWt energy extraction facility at Fenton Hill, New Mexico • Selection of second site for pilot system

10/05/81

PROGRAM: ELECTRIC ENERGY SYSTEMS

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

PROGRAM OBJECTIVES:

The Electric Energy Systems (EES) goals are to provide advanced technology options for future electric networks, develop methodologies for integrating new electric generating and storage technologies into electric utility system design and operations, and improve electric system control. EES research and development activities originated in 1970 in the Department of Interior (DOI) as the Underground Transmission Project. Under the guidance of the Electric Research Council the program scope expanded to reflect the U.S. government's increasing commitment to high-voltage overhead transmission, and to research in systems engineering. EES was transferred from DOI to ERDA under PL 93-438, Energy Reorganization Act of 1977. At this time, the Federal Non-nuclear Energy Research and Development Act, PL 93-577, identified the importance of and need for long-term improvements to the nation's capability for generation, storage and transmission of electrical energy, mentioning, in particular, cryogenic transmission. With this guidance, the role of EES was specified in the 1975 and 1976 ERDA National Plans for Energy Research and Development; its RD&D programs were incorporated in ERDA's Program Implementation Plans. Since then, the EES program has evolved to reflect the policies of the National Energy Plans, in particular the growing importance of electric energy in the nation's future and the need to utilize renewable energy sources.

The principal objectives, activities, funding status, and performance of the program for the period of FY 1978 through FY 1981 are summarized in Table 1. The primary concerns of the program have been, and continue to be: (1) to provide advanced technology options that are critical to the continued functioning of the nation's electricity supply system in normal and emergency conditions, and in a reliable, economic, and environmentally safe manner; (2) to develop advanced concepts to satisfy the nation's electrical needs and which enable the substitution of coal, nuclear, and renewable sources for imported oil; and (3) to perform basic research that increases the efficiency of electrical energy supply and distribution thus reducing primary energy use per unit of real GNP, and which strengthens the U.S. technological base.

There are no other Federal or domestic private sector programs that have duplicative or conflicting objectives although several are related, e.g. objectives such as the DOE Energy Storage program, and research and development programs of the electric utility industry, foreign corporations, and a few large electric utility companies. Within DOE the EES program is coordinated through technical program planning and project management activities with other programs having related objectives. Direct and frequent contacts are maintained within DOE with the renewable technologies, the Health and

Environmental Research office, Bonneville Power Administration, and the Economic Regulatory Administration. In addition, close coordination is maintained with the Electric Power Research Institute (EPRI) and other industry and state research groups. These coordination activities minimize duplication in research activities insure that utility system requirements and constraints are accounted for in electric generation, storage and end-use technology development programs and assure that timely research is carried out by EES to resolve critical technical problems of integrating new technologies into the electric system.

To meet the goals designated by the enabling legislation and current policy, the Electric Energy Systems program is driven by the objectives stated in Table 1 (Historic) and Table 2 (Current). The goals have shifted but little over the past five years, except in the added emphasis now placed on long-term, high-risk research. EES continues to attract private sector research dollars through cost-shared contracts, turning over the engineering development and application work to the private sector at the earliest possible date.

The only other shift from the historical research patterns is the recognition that new dispersed and intermittent electric generation sources and electric storage will require substantial changes in today's transmission and distribution systems, especially in their control and protection during all system contingencies. National security, customer satisfaction, reliability, and public health and safety are all critical in considering the future options.

The strategy of the program is to concentrate on research efforts that will have the greatest impact in meeting the above objectives and that the private sector will not undertake because of excessive risk. In those research activities where utilities and manufacturers are participating, cost sharing at a level commensurate with risk and benefits is required. Close coordination with other DOE programs devoted to the development of advanced electrical generation and storage technologies is required to insure that promising technologies can be effectively integrated into the electrical system and that the performance and operating requirements of the system are accounted for in the technology development process. Beyond this, EES program managers are often relied upon within the Federal government to provide impartial and objective expertise concerning the development, design, and operation of electric energy systems.

PROGRAM IMPACTS:

The initial Congressional direction in establishing the Electric Energy Systems Division was to improve the efficiency and reliability and to reduce the environmental impact of the nation's electric power delivery system. To these were added in recent years the need to integrate renewable, stochastic sources into the electric network and, in consequence, to develop improved methodologies for the planning and control of complex, high-power systems.

These goals have been partially reached through some significant research achievements as shown in more detail in Table 1. Most noteworthy, however, have been the investigation of the effects of high-voltage electric fields on all living organisms, ultimately to humans; the advanced materials and technology, and now the fabrication and test of a 100 meter superconducting cable; construction of the Battery Energy Storage Test (BEST) facility; requirements for controls and communications for satisfactorily placing dispersed and intermittent electric generation on systems designed for central generation only; design and testing of new software for automatically controlling multiple generators and power plants at the Wisconsin Electric Power Company to improve system efficiency and reduce maintenance.

These achievements and others listed in Tables 1 and 2 have and will continue to have major national benefits in improved efficiency, safety, reliability and customer satisfaction. Others will take years - a few may take over a decade - to reach and impact the market. Virtually all projects have involved industry and university participation. Projects with equipment manufacturers and utilities are cost-shared; universities are fully funded by EES to bridge the gap between advanced theory development and applications for critical technical problems. Moreover, support to universities provides a much needed supply of research and engineering professionals.

Thus, directly or indirectly, the impacts of the EES programs affect almost all segments of the United States. The general population benefits through the efforts to make available more efficient, less costly, and more reliable power supplies; the utility industry and their vendors benefit from EES support of advanced technology development that neither can undertake because of high initial risks. The latter impacts are particularly important because of the utility industry's need to reduce the consumption of imported oil, and the equipment suppliers' efforts to establish technical superiority in the face of concerted and well-financed foreign competition.

PROJECTED PROGRAM REQUIREMENTS:

The funding request for FY '82 is $9.9 million. Research to enhance the Nation's electrical supply system, especially in times of national emergency, is of particular concern to the Federal Government because of potential impacts on national security and resulting general concerns for the welfare of all citizens. In the next decade, alternatives in system design and operating methods are required to provide regional power transfer capability from more diverse generating sources and to accommodate shifts in electric demand characteristics. The Electric Energy Systems program will meet the needs of the utility sector by providing options for advanced overhead and underground transmission systems, developing methodologies for integrating new electric generating and storage technologies, and improving electric system control techniques. A modest increase in the level of support, on the order of ten percent (10%), would permit research in advanced communication technology for control of distributed storage and generation systems, accelerate research to reconcile inconsistencies in interspecies studies under exposure to high voltage electric fields, and allow further testing on advanced load leveling batteries. A ten percent (10%) decrease in the level of support will delay the completion of key objectives in 1200 kV transmission technology and in development of cost effective integration of small cogeneration and storage technologies.

Table 2 presents the Program Objectives, FY 1982 and the Division's estimated outyear (FY 1983-1987) costs to accomplish the objectives. The differences between FY '81 and FY '82 programs represent substantial changes in scope and direction. Future EES programs will lay greater stress upon long-range, high-risk research which will provide the foundation for future industrial technological development. Because electricity is so vital to the well-being of the U.S. it is essential that options are available to provide for the nation's needs of the future. Public concern over health and safety, reliability and low cost require innovative research into high-voltage systems, new materials, advanced control schemes, and the like. In today's market where utility load growth is generally small, interest rates high, and state regulatory agencies try to keep rates low, the available risk money for advanced research is extremely small.

DISCONTINUATION REQUIREMENTS:

About ninety percent (90%) of the EES program represents multiyear efforts with long-term commitments; most of the efforts are funded in phases of yearly increments. For example, EES has a long-term project with the Massachusetts Institute of Technology to develop a prototype superconducting electric generator; this project has been funded for eight years and requires another four years at $2 million per year to complete. Approximately ten percent (10%) of the EES programs could be discontinued with marginal savings; the remainder would cost more to terminate than to continue and should be considered for funding to completion. To meet the FY '82 budget of $9.9 million, close-out costs for projects in place in FY '81 are estimated to be between $20-25 million. There are no legislative changes required to terminate the EES program.

TABLE I
ELECTRIC ENERGY SYSTEMS
PROGRAM ACCOMPLISHMENTS

Goals/Objectives	Other Programs (Duplicative)	BUDGET DATA ($ millions) STATUS				Degree Original Objective Met
		FY 78	FY 79	FY 80	FY 81	
		41.6	30.0	27.3	30.0	
System Architecture and Integration						
• Complete assessment of dispersed storage and generation integration requirements by 1980.	• None	Preliminary determination of steps and magnitude of integration problem	Integration assessment methodology developed	Integration issues identified and priorities assigned	Data Base R&D Program Plan prepared	• Assessment completed and documented
• Complete integration studies for solar photovoltaics and wind generation by 1981 and for OTEC by 1990.	• None	Initiate study of impact of harmonics from DSG on customer equipment	Initiate study to determine impact of DSG on distribution system safety and protection	Initiate study to determine impact of DSG on distribution system planning and design	Initiate study to determine control hierarchy for DSG	• Objective cannot be met with present budget
• Develop communication technology for dispersed generation, storage and end-use management in utility distribution systems by 1987.	• None	Develop measuring equipment to determine circuit communication capability	Preliminary investigation of power communication systems	Define communication and control requirements for DSG	Complete field tests of first generation distribution communication equipment	• Objective cannot be met with present budget
• Assess advanced control concepts for energy management in utility distribution systems by 1983.	• None	Complete negotiation of Interagency Agreement with TVA	Complete specification of test bed and select location	Complete review of conventional equipment and practices	Complete specification of control system requirements	• Project on schedule
• Improve system efficiency, reliability, and adaptability under normal and emergency conditions.	• None					
- Complete automatic generation control software by 1981 and demonstrate 1% efficiency improvement by 1987.		Developed computer models of Wisconsin Electric Power (WEPCO) system	Developed control algorithms for integrated load frequency control/economic dispatch	Tested and evaluated control algorithms via computer simulation	Prepared operating software, installed programs on control computer, and began performance evaluation	• Software debugged running; evaluation in progress.

TABLE I (continued)

ELECTRIC ENERGY SYSTEMS

PROGRAM ACCOMPLISHMENTS

Goals/Objectives	Other Programs (Duplicative)	BUDGET DATA ($ millions) STATUS FY 78	FY 79	FY 80	FY 81	Degree Original Objective Met
		41.0	39.0	37.3	39.9	
Power Delivery						
• Develop 1500 kV cryogenic cable technology by 1985.	• None	Complete economic study of underground alternatives	Initiate 1500 kV gas cable design research	Complete feasibility studies	Completed cable design, and finish test protocol	• Concept in ground, cable can be made in laboratory
• Complete OTEC riser cable conceptual design by 1981.	• None	Outline project	Complete engineering studies	Determine electro-mechanical problems for floating platform	Complete conceptual designs	• Concept and designs are feasible in lab tests
• Complete construction of superconducting cable test facility by 1981.	• None	Completed lab demonstration of high current test; terminated work on rigid and vacuum insulated superconducting cables after thorough economic analysis	Completed test site of BNL. Initiate cable fabrication	Tested 100 meter long cryogenic enclosure at rated temperature (8°K)	Completed fabrication of 100 meter long cable	• Cable concept proven in lab, cryostat and refrigeration tested under field loading
• Resolve electric field effect questions with laboratory experiments and human risk assessment by 1984.	• None	Completed initial studies on biological effects on small animals	Observed significant biological change in blood chemistry of rats in electric fields	Published preliminary biological effects on large and small animals	Completed ground studies of effects on small animals	• First level effects noted, providing pattern for continued genetic and biological work to determine human risk
• Assess feasibility of amorphous metal applications to transformers and electric motors by 1984.	• None	Outline project	Feasibility of low loss material composition and benefits assessment initiated	Develop process for amorphous metal flakes	Develop feasible process for helical metal ribbon for motors, and evaluate potential for transformers	• Lab process developed, and loss evaluation for optimal benefits completed
Conservation and Storage Analysis						
• Demonstrate benefits of conventional versus advanced batteries by 1983.			Initiated R&D on Zn/Cl battery (Phase I) for BEST	Completed initial design of Zn/Cl battery load leveling	Completed Phase I Zn/Cl battery development	• Confirmed conceptual feasibility of Zn/Cl battery for load leveling application
- Complete construction of Battery Energy Storage Test (BEST) laboratory building, including first test bay, by 1981.	• None	Planned and began construction of BEST laboratory	Continued construction of BEST laboratory	Continued construction of BEST laboratory	Completed construction of BEST. Dedicated May 1981	• Exterior BEST lab construction completed. Lead-acid batteries installed Available for station checkout.

TABLE I

ELECTRIC ENERGY SYSTEMS
CURRENT PROGRAM OBJECTIVES AND BUDGET
($ millions)

Budget FY 82 $ 9.0
Estimated Outyear Costs $195.0

Goals/Objectives	Alternative Methods	Anticipated Needs (for Objective Target Date)	(Hypothetical) Budget Justification and Services Provided
System Architecture and Integration			
• Develop methodologies to include new technologies in power system design and operation.			
- Complete wind and photovoltaic integration methodologies by 1987.	• Rely on electric utilities, EPRI and trade associations to develop new technology integration methodologies.	• Identifies by 1983 key issues to be resolved for successful integration with the electrical system.	• Identification of distribution system safety and protection requirements to integrate new technologies into the electric system.
		• Provides advanced concepts and data for planning and operating the power systems of the future.	• Wind and photovoltaic integration methodologies complete.
- Develop power conditioning methods for small cogenerators with cost goal of $200/kW by 1983.	• Rely on private sector to develop power conditioning equipment for small generating technology.	• Defines direct current source interface requirements with the alternating current system, and develops power conditioning interface hardware.	• Development of power conditioning methods and hardware specifications for small direct current cogenerators.
• Develop unified theory of human and automatic control of power systems by 1990.			
- Complete large scale system simulator by 1983.	• Rely on private sector and universities to define and complete basic theory.	• Identifies basic research issues in large electric system control and operation, including human operator characteristics.	• Continuation of large scale systems applicable to power operation and control.
		• Develops advanced process models and control simulation for highly promising concepts.	• Evaluation of multivariable plant controller designs.
		• Provides improved reliability and control of very large systems.	• Development of very large system stability assessment.

TABLE 3 (continued)

ELECTRIC ENERGY SYSTEMS

CURRENT PROGRAM OBJECTIVES AND BUDGET

($ millions)

Budget FY 80 $ 9.0

Estimated Outyear Costs $191.0

Goals/Objectives	Alternative Methods	Anticipated Needs (for Objective Target Date)	(Hypothetical) Budget Justification and Services Provided
Power Delivery			
• Investigate high-risk transmission options for 1985 utility planning assessments.			
- Complete development of 1200 kV technology (semiflexible cable, circuit breaker, gas transformer, direct current transmission).	• Rely on domestic industry to develop technology.	• Identify requirements for 1200 kV transmission technology	• Increased electric power transfer over longer distances at improved levels of stability.
	• Increase reliance on foreign suppliers for advanced transmission technology.	• Perform basic studies on insulating gases.	• Identification of improved insulating gases for underground electric transmission cables.
	• Maintain 500 kV/765 kV system with additional installations and transmission lines.	• Quantify direct current transmission benefits as an overlay to alternating current systems.	• Fundamental investigations of high voltage direct current interruption techiques.
		• Accelerate development of higher efficiency conductive materials.	• Continuation of research in the use of higher efficiency amorphous materials in electric transformers and motors.
- Conduct a laboratory test to determine the technical feasibility of superconductivity for electric transmission and generation by 1984.	• Rely on private sector to initiate superconducting transmission tests.	• Conduct laboratory tests of superconducting cable.	• Fabrication and testing of 100 meter long, 138 kV superconducting cable.
	• Increase reliance on foreign suppliers.		• Development of high power transfer underground cable systems.
• Complete statistical exposure analysis of electric field effects on small animals by 1983.	• Transfer Federal research in transmission lines electric field effects to another Federal agency.	• Publish objective, unbiased research to identify electric field effects on living organisms.	• Reconcile simulation inconsistencies in interspecies electric field effects.
			• Continuation of circadian rhythm studies on rats and mice exposed to electric fields.

TABLE 2 (continued)

ELECTRIC ENERGY SYSTEMS

CURRENT PROGRAM OBJECTIVES AND BUDGET

($ millions)

Budget FY 82 $ 9.9

Estimated Outyear Costs $100.0

Goals/Objectives	Alternative Methods	Anticipated Results (for Objective Target Date)	(Hypothetical) Budget Justification and Services Provided
Generation and Storage Analysis			
• Complete the second bay of the Battery Energy Storage Test (BEST) laboratory by 1982. Continue test of advanced batteries for utility load leveling applications.	• Transfer activity to utilities and EPRI.	• Quantified performance characteristics of advanced flow battery and power processing.	• Quantification of benefits and evaluation of battery station performance on a utility system.
• Complete Phase III integration design of the zinc/chloride battery by 1982 having a minimum electrochemical efficiency of 65% and greater than 250 charge/discharge cycle of stable performance.	• Transfer activity to utilities and EPRI.	• Evaluates advanced load leveling concepts (battery storage) for use by utilities.	• Development of advanced battery design.

OCT 7 1981

VOLUME 2, PHASE II

PROGRAM: Energy Storage Systems

- o Electrochemical Energy Storage
- o Physical and Chemical Energy Storage.

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

OBJECTIVES:

The historic goal of the Energy Storage Systems Program has been to develop energy storage technologies and demonstrate, in cooperation with industry, reliable, cost-effective and environmentally acceptable storage systems to increase the substitution of coal, nuclear, and renewable energy resources for petroleum, enable intermittent renewable energy sources to provide continuous service, and improve productivity of energy supply and end-use technologies.

The original legislative mandate for energy storage technology development was the Federal Non-Nuclear Energy Research and Development Act of 1974 (P.L. 93-577, Sec. 6), which directed the development of "advanced energy ... technologies" in the area of batteries for electric vehicles, energy storage for electric utility load-leveling applications, and thermal energy storage for use in residential and commercial systems. Other acts extended the storage subprogram efforts: the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409, Sec. 6); the Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976 (P.L. 93-413); the Solar Photovoltaic Energy Research, Development and Demonstration Act of 1978 (P.L. 95-590); the National Energy Conservation Policy Act of 1978 (P.L. 95-619, Title VI); the Energy Security Act of 1978 (P.L. 95-294); and the Ocean Thermal Energy Conversion Research, Development and Demonstration Act of 1979 (P.L. 96-310, Sec.9).

The historic objectives of the program are presented in Table 1. Current objectives, listed in Table 2, differ from original objectives primarily in increased emphasis on long-term R&D. Projects directed toward near-term applications have been curtailed, and proposed demonstration projects eliminated. There have, of course, been some redefinitions as objectives were achieved, new breakthroughs or barriers identified, and as technologies became ready for transfer to the private sector.

The Electrochemical Energy Storage program element will provide a strong technology base by supporting research in electrochemical energy storage; improve energy density (electric vehicle range), power

95-882 O—82——51

density (electric vehicle acceleration), life (number of cycles) in electrochemical cells; and develop and improve the life and cost of various batteries for electric utility/solar applications.

The Physical and Chemical Energy Storage element will provide a technology base by supporting research and exploratory development in the areas of thermal, chemical, mechanical, underground, and magnetic energy storage for use in utility, residential/commercial, transportation, and industrial areas.

Only private sector activities can be considered as a real alternative to the Federal program. However, the private sector is unlikely to invest in the R&D projects of this program because most projects have large potential benefits only far into the future. Also, the risks are not at an acceptable level for individual projects in which a single firm might invest. In many cases, potential benefits (e.g., contribution to national energy security) are large enough to justify Federal R&D investment, but private benefits to an investing firm are too small or too risky due to the generic nature of the research.

An attempt to encourage private industry R&D investment through end product regulatory legislation appears inappropriate due to the early stage of the development of storage technologies.

There are other DOE programs, non-DOE Federal programs, private sector, and international activities related to the goals and objectives of the energy storage effort. These other programs are listed in Table 1 and are carefully integrated by appropriate organizations such as the DOE Hydrogen Energy Coordinating Committee. Energy Storage Systems management considers coordination of effort with related R&D areas (e.g., Transportation) as a major part of their administrative responsibilities.

PROGRAM IMPACTS:

By providing the capability for improving both energy process efficiency and flexibility in energy management, the storage program will have an impact on the national economy; in particular, in the electric car and utility industries and in the solar photovoltaic and wind energy systems. The program provides an additional design option for industrial processes and for both energy production and distribution.

Technologies sufficiently developed (e.g., improved near-term lead-acid batteries and customer-side-of-the-meter thermal energy storage) have been transferred to the private sector. Where the private sector showed sufficient interest (e.g., EPRI's current support for high-head turbine technology for underground pumped storage), further development has been transferred to the private sector.

If the research and development within the Energy Storage Systems program is successful, the private sector will be presented with a variety of options with which to build a new industry--that of energy storage. The beneficiaries will include, directly and indirectly, the entire population. In the transportation area, the benefits will first extend directly to commuters and to businesses that use vehicles for short-haul pickup and delivery. In the electric utility/solar applications area, the benefits of energy storage systems for utility and solar applications could extend to every household and business in the country, as well as to the utilities themselves. In the industrial area, the benefits of electrochemical technology R&D, for example, will go to the chlor-alkali and aluminum industries which use 25 percent and 65 percent, respectively, of the electricity consumed in the industrial electrolytic sector. Thermal energy storage will be used in many industries to permit recovery and use of waste heat.

The net health and safety impacts for the Energy Storage program will generally be positive. For example, in transportation systems, there would be a reduction in both exhaust emissions and noise levels, compared to the use of the internal combustion engine. Environmental impact studies made to date have shown that storage technologies tend to be relatively safe.

The Energy Storage Systems program is implementing the major intent of the legislation enacted by Congress. Table 1 shows the continuous progress that has been made toward the objectives since program inception. Performance and accomplishments for the years 1978 through 1981 are also summarized in Table 1. Since 1978, $216 million has been expended on these efforts.

PROJECTED PROGRAM REQUIREMENTS:

The Energy Storage Systems program funding request for FY 1982 is $38.5 million. This funding level (which is the lowest in the last five years) reflects the changes in program focus discussed above, and, if sustained through the mid-1980s, should provide adequate support for the long-term, exploratory R&D necessary to achieve currently defined program objectives. Where the Federal R&D program has reduced the technical and economic risks, the private sector will be expected to complete the development and commercialization process.

The FY 1982 requested budget ($26.5 million) for the Electrochemical Energy Storage element is justified in terms of the net benefit attainable in energy savings. The total yearly savings by the year 2000 is estimated to be 375 MBOE* per year. These savings are based on the known and projected levels of energy consumption in the areas where storage may be employed, the estimated fraction of market penetration that can be anticipated, and the effect on the energy supply of

*Million barrels of oil equivalent.

the addition of the storage systems. The savings are thus based on a series of projections and assumptions and only represent the general magnitude of potential savings. Of the total savings, transportation (electric vehicles) contributes 170 MBOE per year; utility and solar applications 25 MBOE per year; and industrial electrolytic processes, 180 MBOE per year. It is estimated that it will cost $160 million (1982 through 1988) to complete the current projects. Current goals/objectives and future activities are shown in Table 2.

The FY 1982 requested budget for the Physical and Chemical Energy Storage element is $12.25 million. This R&D funding is also justified by the net benefits attainable in energy savings. The total yearly savings by the year 2000 is estimated to be 160 MBOE per year. Of this total, building heating and cooling contributes 35 MBOE per year; transportation contributes 30 MBOE per year; industry contributes 20 MBOE per year; and utility and solar applications contribute 75 MBOE per year. It is estimated that it will cost $82 million (1982 through 1988) to complete the current projects. Current goals/objectives and future activities are as shown in Table 2.

The proposed Energy Storage Systems program represents a critical core of effort. Increasing the level of funding by 10 percent or $3,850,500 would allow the acceleration of storage development with enhanced probability of success. In the Electrochemical area the additional funds would be added to the current projects. Decreasing the funding by 10 percent would cause the cancellation of the lithium/metal sulfide battery activity which could result in no high temperature battery being available for transportation applications if the sodium/sulfur system were found to be unsuitable. Additionally, a decrease in funding would delay the availability of batteries for use in electric utility load-leveling. In the Physical and Chemical program element, additional funding would permit completion of the adiabatic compressed air energy storage project. A decrease in funding would result in the elimination of the flywheel project, which would cause a delay of approximately a decade before application in the transport sector.

DISCONTINUATION REQUIREMENTS:

The transitional requirements, in the event that funding is discontinued, would need to be determined on a project-by-project basis. It has been estimated that discontinuation of the program would result in contract close-out costs of $7 to $8 million. These costs result from government default on contracts with industry and from discontinuing activities at national laboratories. Also, the termination of storage programs would impact other DOE programs (e.g., transportation, utilities, and solar energy) that are dependent upon energy storage research.

In the area of legislative action, the Congress has mandated many of the Energy Storage research and development activities, either directly or by implication; amendment of existing legislation would be required to rescind these requirements.

Table 1. [illegible]rgy Storage Systems
Subprogram Accomplishments

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	PERFORMANCE AND FUNDING STATUS FY 78 $43.1M (Total Energy Storage Systems Program)	FY 79 $58.0M	FY 80 $65.0M	FY 81 $49.9M	DEGREE TO WHICH OBJECTIVES MET
A. **Electrochemical Energy Storage**		$16.5M	$25.4M	$33.1M	26.2M	
o Provide a technology data base by supporting applied research in electrochemical energy storage and conversion		Improved lead-acid batteries into experimental development	Zinc-bromine batteries into experimental development	Lithium metal sulfide batteries into experimental development	Sodium-sulfur batteries into experimental development	Technology base objectives for these systems have been met.
- Develop improved industrial electrolytic processes for chlor-alkali and aluminum industries					Improved oxygen electrodes in testing.	Transfer to chlor-alkali industry in 1982.
				Hall cell research phase completed	Improved Hall cell in scale-up phase.	Transfer to aluminum industry in 1985.
- Conduct corrosion research and electro-organic syntheses					Preliminary assessments in process.	Laboratory work to begin in FY 1982.
o Develop and improve batteries for EVs with long life, high energy, power density, and maintain a technology base.	Coordinated with Electric & Hybrid Vehicle Program					Future costs of all EV batteries in development are projected to fall within cost goals.
- Lead-acid, nickel/iron and nickel-zinc batteries 1985						
Energy Density (Wh/kg) 56		35	41	42	42	Test batteries have reached up to 75% of their goal in energy density and 100% in power density. Work on cycle life is continuing.
Power Density (W/kg) 104		-	90	104	104	
Cycle Life (cycles) 800		-	170	400	600	
Cost ($/kWh) 70		-	-	-	-	
- Lithium/metal sulfide and sodium sulfur 1990						
Energy Density (Wh/kg 125		90	80	70-80	90	Test batteries have reached up to 72% of goals in energy density, 60% in power density, and 50% in cycle life.
Power Density (W/kg) 150		60	55	80	90	
Cycle Life (cycles) 800		80	200	300	400	
Cost ($/kWh) 77-88		-	-	-	-	

Table 1. Energy Storage Systems
Subprogram Accomplishments (continued)

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	PERFORMANCE AND FUNDING STATUS (Total Energy Storage Systems Program) FY 78 $43.1M; FY 79 $58.0M; FY 80 $85.0M; FY 81 $49.9M	DEGREE TO WHICH OBJECTIVES MET
- Metal-air 1995 Energy Density (Wh/kg) 360 Power Density (W/kg) 150 Cycle Life (cycles) 800 Cost ($/kWh) -		Energy density (projected for 1985 on the basis of current laboratory tests): 152 Wh/kg at a battery cost of $35-40/kWh.	Metal-air batteries are in the early development stage; battery performance data will be available in 1982.
• Develop and improve batteries for utility/solar applications with improved cycle life, decreased cost. Maintain technology.	Coordinated with Electric Energy Systems, Physical and Chemical Storage Program, Solar Energy-Photovoltaic and Wind Energy		Costs of future utility/solar batteries are projected to fall within cost goals. Percentage attainment of cycle life goals are low because these programs are in the early stages.
- Lead-acid 1985 Life (yr) 10 Cost ($/kWh) 100-125		Lead-acid life testing in progress.	Lead-acid batteries have achieved 25% of life goals.
- Zinc/bromine, lithium/metal sulfide, redox, and sodium sulfur 1990 Life (yr) 20 Cost ($/kWh) 70		Life testing in progress on all these battery types.	Sufficient data will be accumulated in FY 1982 to enable determination of life-times.

Table 1. Energy Storage Systems Subprogram Accomplishments (continued)

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)*	PERFORMANCE AND FUNDING STATUS				DEGREE TO WHICH OBJECTIVES MET
		FY 78 $43.1M	FY 79 $58.8M	FY 80 $65.0M	FY 81 $69.9M	
		(Total Energy Storage Systems Program)				
B. Physical and Chemical Energy Storage		$26.M	$32.6M	$31.9M	$23.6M	
o Develop four storage technologies for solar and conventional electric utility applications:						
- Compressed Air Energy Storage (CAES) -- Complete conceptual design by 1981 and initiate experiments of no-oil concepts by 1984	Electric Energy Systems joint site studies with PCES on CAES and UPH for utilities. EPRI R&D for CAES and UPH coordinated and/or cost-shared with PCES.	Completed state-of-the-art surveys and formulated reservior criteria for CAES.	Completed advanced CAES equipment evaluations, developed preliminary CAES design.	Completed numerical modeling and laboratory investigations of CAES reservoirs.	Started field experiments on the injection and storage of compressed air in porous rock media.	One design completed; baseline technology being transferred to private sector. Conceptual studies on no-oil concepts and field studies on aquifers for CAES in progress.
- Underground Pumped Hydroelectric (UPH) -- Complete site exploration and plant design by 1983.	Same as above.	Completed UPH system studies and identified turbine and need for improved efficiency and operating head.	Began studies of improved machinery efficiency and operating head; completed reservoir geology study.	Completed site exploration study and preliminary design of a UPH storage plant.	Project completed; results transferred to utilities, (EPRI).	Objectives met: One site explored and design study completed by 1981. The technology for high head turbines has been transferred to industry and is now supported by EPRI.
- Superconducting Magnetic Energy Storage (SMES) -- Proceed with device development and analyze performance tests of a small 30 MJ unit by 1983.	R&D on magnetic storage stabilization for power transmission coordinated with Bonneville Power Administration. PCES and EPRI cooperating on assessment of large scale utility magnetic energy storage.	Performed technical applications analysis of SMES.	Selected 30 MJ SMES unit for transmission line stabilization; initiated engineering design.	Completed SMES design for line stabilization and initiated development.	SMES subunits fabricated and testing begun.	Fabricated all subunits for 30 MJ system to be integrated into a total system for engineering testing. Site preparation is in progress.

*Coordinates where overlaps occur.

Table 1. Energy Storage Systems Subprogram Accomplishments (continued)

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)*	PERFORMANCE AND FUNDING STATUS				DEGREE TO WHICH OBJECTIVES MET
		FY 78 $43.1M	FY 79 $58.0M	FY 80 $65.9M	FY 81 $49.9M	
		(Total Energy Storage Systems Program)				
II. Physical and Chemical Energy Storage						
- Thermal Energy Storage (TES) -- Develop storage for solar power applications for 1985.	Performs research in support of Solar Thermal Energy program goals on pass-through funding basis.	Completed evaluations of storage media; selected a eutectic salt and transfer fluid.	Completed conceptual design and evaluation study for utility peaking application.	Completed design and fabrication of an active heat exchanger system using phase change materials.	Completed engineering performance testing of a molten salt heat storage unit.	Molten nitrate salt selected as most promising storage medium. Established design and evaluated performance parameters.
o Develop two storage technologies for 1) daily and 2) seasonal application in heating and cooling buildings:						
- Daily:						
Chemical Heat Pumps -- Confirm feasibility for heating and cooling with storage in large and small buildings by 1981.		Completed experimental studies on a series of chemical reactions; identified 4 most promising for further research.	Completed technical and economic evaluation of advanced heat pump systems; selected 2 for further development.	Completed laboratory testing of 100,000 Btu methanol-calcium chloride heat pump (over 100 cycles).	Completed laboratory testing of 150,000 Btu/hr (1 MM Btu storage capacity) sulfuric acid-water heat pump.	Achieved objective: Built prototype methanol-calcium chloride unit and operated successfully. Ready for transfer to private sector.
Thermal Energy Storage (TES) -- Test feasibility of using sensible heat storage for customer-side storage utility load-leveling applications in near term.	Electric Energy Systems, in coordination with PCES, studied utility side control strategies and interface technology.	Initiated design and implementation of field test experiment in New England.	Performed preliminary analysis of system cost and performance.	Completed experiment; collected 2 seasons' data; performed customers acceptance survey.	Analysis of 2 seasons' data on cost and performance.	Field tests completed; performance characteristics and costs quantified. Transferred to private sector. Several utilities now promoting with special off-peak rates.
				Established calorimeter for full-scale testing of TES device.	Results from calorimeter measurements used to establish inputs for ASHRAE test procedures for rating TES devices.	

*Coordinated where overlaps occur.

Table 1. Energy Storage Systems Subprogram Accomplishments (continued)

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)*	PERFORMANCE AND FUNDING STATUS				DEGREE TO WHICH OBJECTIVES MET
		FY 78 $43.1M	FY 79 $58.0M	FY 80 $65.0M	FY 81 $49.0M	
		(Total Energy Storage Systems Program)				
B. Physical and Chemical Energy Storage						
Evaluate phase change materials and technologies for thermal storage at a capital cost of $5/kWht by 1985.		Developed chub containment method for hydrated salts for phase change storage material.	Completed a preliminary evaluation of selected advanced thermal energy storage technologies.	Developed form stable polyethylene pellets for heat storage at an estimated cost of $24/kWh.	Completed evaluation of available thermal storage units for off-peak power operation in residential heating. Completed evaluation of industrial waste heat with storage for district heating.	Cost objective can be met for low temperature applications, lifetime needs improvement.
- Seasonal:						
Seasonal Thermal Energy Storage -- Establish feasibility of heat and chill storage in aquifers (this was unknown technology, tentative objective of 70% recovery efficiency by 1986 was set).	HUD undertook to identify and evaluate potential role of storage as part of district heating projects.	Closed cycle heated/chill injection/withdrawal experiments.	Assessed applications and selected regional sites.	Completed nationwide aquifer storage demonstration site selection.	Completed field experiments with heated and chilled water, and established that storage capital cost will be less than $0.01/kWh for heat and $0.10/kWh for chilling.	First seasonal heat storage experiments completed and functional data collected. One cycle of seasonal cool storage experiment completed; technical problems under investigation. Measured efficiencies of 27-63%, depending on temperature level.
o Develop two storage technologies for use in vehicles:						
- Mechanical storage (flywheels and elastomers) Develop 88 Wh/kg flywheel rotors for stationary and mobile applications by 1982.	Mining applications of flywheels being tested by Powell Energy. DOT sponsors work on trolley bus. R&D on flywheels was part of DOE's Advanced Vehicle Development Project on the ETV-2.	Determined mechanical energy storage system performance criteria for vehicle applications.	Evaluated performance of two advanced flywheel regenerative braking prototypes in the laboratory.	Achieved a 25% increase in electric vehicle range over the urban driving cycle.	Completed experimental testing of three advanced composite flywheel rotor designs.	88 Wh/kg goal met in FY 1981.

*Coordinated where overlaps occur.

Table 1. En Storage Systems Subprogram Accomplishments (continued)

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)*	PERFORMANCE AND FUNDING STATUS				DEGREE TO WHICH OBJECTIVES MET
		FY 78 $43.1M	FY 79 $50.0M (Total Energy Storage Systems Program)	FY 80 $65.6M	FY 81 $49.5M	
II. Physical and Chemical Energy Storage						
- Hydrogen Energy Storage -- Develop and evaluate hydrogen storage concepts for vehicular applications.	Coordinated by IEA and by DOE Hydrogen Energy Coordinating Committee	Co-selected Fe-Ti stationary storage unit and evaluation requirements for mobile applications.	Evaluated Mg hydride and Mg/Fe-Ti hydride storage systems. Identified hydrides as a resource recovery system for obtaining hydrogen from refining and synfuels production waste streams.	Evaluated glass microspheres for hydrogen storage.	Program terminated.	Material studies and evaluations completed; could not meet both cost and performance objectives simultaneously.
o Develop three energy technologies for industrial and multi-purpose applications:						
- Thermal Energy Storage -- Develop materials and components for recovery of industrial process waste heat at cost of less than $5/kWht by 1987.		Completed assessment of ceramics industry.	Completed assessment of thermal storage in five industrial areas.	Determined feasibility of carbonate for high temperature latent heat storage. Results transferred to food processing industry.	Completed technology transfer of thermal energy storage to paper and pulp industry. Being implemented in 1 plant, evaluated for 5 plants.	All near-term applications studies are complete. Technology transferred to two industries.
- Hydrogen Production - Design and test efficient (>80%) electrolysis for hydrogen production by 1984 at cost of $130/kW and lifetime of 5 years. Evaluate thermochemical cycles for hydrogen production.	Coordinated by DOE Hydrogen Energy Coordinating Committee.	Completed scale up of advanced electrolyzer modules to 2.5 ft^2; completed preliminary analysis of hydride thermochemical cycles.	Characterized performance of the multicell electrolyzers; operated two complete thermochemical cycles at the laboratory scale.	Completed construction of advanced RPEC electrolyzer, established costing model for electrolyzers (200 kW system).	Tested and evaluated an electrolyzer unit; completed all bench scale units for one thermochemical cycle. DOE program being terminated; work continuing with co-sponsors.	200 kW test unit operated. Efficiency goals met in single cells for short periods. Lifetime objective not met; cost objective unattainable.
- Hydrogen Storage and Transmission -- Determine hydrogen compatibility with existing pipelines and develop improved materials.	Same as above.	Completed hydride stationary storage unit.	Completed studies on hydride poisoning and on underground storage.	Initiated hydrogen embrittlement study for natural gas pipelines.	Completed first phase of materials study for hydrogen transmission.	Preliminary materials studies completed.

*Coordinated where overlaps occur.

Table 2. Energy Storage Systems
Subprogram Current Objectives and Budget

GOALS/OBJECTIVES	ALTERNATIVES	ANTICIPATED NEEDS (for Objective Target Date)	BUDGET JUSTIFICATION AND SERVICES PROVIDED
A. ELECTROCHEMICAL ENERGY STORAGE			Budget FY 82 $26.55 million
Technology Base Activities			
Provide a strong technology base in support of the EV, utility, and solar mission oriented efforts.	Rely on private sector to develop needed technology.		
Develop improved industrial electrolytic processes for the chlor-alkali and aluminum industries.		Transfer improved oxygen cathode to chlor-alkali industry in FY 82. Transfer improved Hall cell to aluminum industry in FY 85. Transfer processes to industry in FY 90.	
Develop new electro-organic synthesis processes and electrochemical corrosion control techniques.			
Electric Vehicle			
Improve existing battery systems and develop new battery systems in the Technology Base programs with the following characteristics: Energy Density (W/kg): 1985 70, 1990 120, 1995 200 Power Density (Wh/kg): 1985 120, 1990 150, 1995 150 Cycle Life (cycles): 1985 800, 1990 800, 1995 800	Rely on private enterprise to develop needed technology	Complete fabrication of lithium/metal sulfide batteries for EV testing in FY 84. Develop full sized metal-air modules for EVs in FY 85 and begin tests in FY 86	Estimated cost to complete is $180 million The continued funding of this program is fully justified in terms of the discounted net energy benefit attainable in terms of oil and gas savings between 1981 and 2000.
Utility and Solar Applications			
Identify new electrochemical couples and develop technology base. Develop improved batteries for utility/solar applications with the following performance criteria: 1985: Life (yr) 10, Cost ($/kWh) 100 1990: Life (yr) 20, Cost ($/kWh) 70	Utilities: develop more costly site-constrained storage technologies. Solar thermal storage	Complete zinc/bromine prototypes for photovoltaic systems: 10 kWh, FY 82; 20 kWh, FY 83. Test 5 MWh sodium/sulfur battery in battery energy storage test (BEST) facility in FY 86. Complete 10 kWh Redox prototype for photovoltaic systems in FY 83.	

Table I. Energy Storage Systems (continued)
Subprogram Current Objectives and Budget

Goals/Objectives	Alternatives	Anticipated Needs (for Objective Target Date)	Budget Justification and Services Provided
B. PHYSICAL AND CHEMICAL STORAGE			**Budget FY 82 $12.25 million**
Thermal Energy Storage			
Develop phase change storage components for heating and cooling of small buildings at a capital cost of $5/kWht by 1988	Rely on the private sector to develop the technology	New and improved methods for cycling and packaging phase change materials	Allow for the incorporation of phase change materials in building materials for savings in heating/cooling energy requirements
Chemical Energy Storage			
Develop chemical heat pump components for heating and cooling of large buildings and upgrading waste heat by 1985	Rely on the private sector for technology development	Improvements in the cycling of reversible chemical reaction, diminish corrosion effects and increase heat transfer rates	Energy utilization efficiency would be improved by chemical heat pump utilization of solar/industrial waste heat
Provide technical feasibility for a process for hydrogen production from water at a cost of $9/Mtu by the year 2000	Rely on the development of other synfuels	Improved technological development of electrolysis and thermochemical processes apparatus	Support of component R&D for efficient water splitting via electrolysis and thermochemical methods
Mechanical/Flywheel Energy Storage			
Develop composite flywheel rotor technology with an energy density of 90 Wh/kg by the year 1985	Rely on the private sector for technology development	Improvements in rotor design	Support material structure, fabrication and reliability testing of components
Underground			
Develop base technology for seasonal storage leading to potential capital cost of $0.01/kWht for hot water storage and $0.10/kWht for cold water	Rely on the private sector for technology development	Completion of experimental field tests to evaluate system feasibility	Support of modeling and experimental work to determine feasibility and efficiencies
Magnetic Energy Storage			
Develop superconducting magnetic energy storage technology and transmission line stabilization by 1983	Rely on the private sector or Electric Power Research Institute to sponsor the development	Completion of the stabilization unit's fabrication	Support experimental work and fabrication of a transmission line stabilization unit

OCT 15 1981

PROGRAM: Buildings and Community Systems
ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy

OVERVIEW:

Buildings and Community Systems (BCS) is comprised of programs conducted by two separate offices: the Office of Buildings Energy Research and Development (BERD) and the Office of Urban Waste. BERD includes R&D, incentive, information and regulatory programs which accelerate the rate of efficiency improvement of buildings, appliances and energy delivery. The Office of Urban Waste is chartered to accelerate the use of municipal waste as an energy source. In addition, this office increases the technical options available for conservation of energy and other resources through waste treatment processes.

Buildings Energy Research and Development

PROGRAM OBJECTIVES:

Energy used in the operation of residental and commercial buildings accounted for more than 35 percent of total U.S. energy consumption in 1980, or 27 quadrillion BTU's. The historic goal of BERD has been to moderate the growth in energy consumption by this sector. The approaches used to accomplish this goal have been to accelerate the adoption of energy conservation technologies, energy delivery techniques and behavior through R&D, information, incentive and regulatory programs. These programs have been funded under the following budget line items: Building Systems, Community Systems, Small Business, Technology and Consumer Products, Appliance Standards, Analysis and Technology Transfer, Federal Energy Management, Residential Conservation Service, Residential/Commercial Retrofit, and Energy Impact Assistance.

Enabling legislation for BERD derives from eight principal sources. These are: the Non-Nuclear Energy Research and Development Act of 1974, P.L. 93-577; the Energy Reorganization Act, P.L. 93-438; the Department of Energy Organization Act, P.L. 95-91; the Energy Conservation and Production Act, P.L. 94-385; the Energy Policy and Conservation Act, P.L. 94-163; the National Energy Conservation Policy Act, P.L. 95-619; the Powerplant and Industrial Fuel Use Act, P.L. 95-620; and the Energy Security Act, P.L. 96-294.

Historically, the Office of Building Energy Research and Development's objectives have been: to reduce energy consumption in new and existing buildings by 30 and 20 percent, respectively, between 1978 and 1985; to reduce the average energy consumption in existing federal buildings by 20% and in new federal buildings by 45% between 1975 and 1985; to encourage information dissemination on conservation related services through public utilities, private firms and associations; to cost-share research on energy efficient designs for appliances in order that a 30% reduction in energy consumption in new building equipment will occur between 1978 and 1985; to develop buildings and appliance test procedures and computer models of buildings energy

performance; to develop energy related standards for appliances and buildings; to assist communities and small businesses with energy management by disseminating information on efficient energy management methods; to develop more efficient community energy delivery systems; to plan and demonstrate district heating technologies; to reduce the average energy use in federal operations and buildings; and to provide financial assistance to communities experiencing growth related problems from expanded energy production activities. Substantial progress has been made towards achieving the historic program goals of BERD. As described in detail on table 1, a number of research, information and regulatory objectives have been initiated or completed, contributing to energy efficiency in buildings, equipment and energy delivery systems.

The current objectives of BERD are: to advance the understanding of building performance through long-term R&D, thereby increasing the technical options available in the market place; to develop and improve computer models of building energy performance; to develop improved appliance and building test procedures; to provide information to the buildings services industry and to develop 10-year energy plans for Federal buildings. As reflected in the current objectives of table 2, there has been a reduction in scope of effort for information, demonstration and regulatory programs while long-term research programs that address building and equipment technology development are retained. Essentially, BERD activities now place significantly less emphasis on information or demonstration and more emphasis on high risk R&D efforts.

The work efforts within BERD are coordinated with other DOE programs such as the Active Solar Heating and Cooling and Passive and Hybrid Solar programs. All of these programs are concerned to some degree with more efficient use of energy in buildings. However, BERD efforts have focused on research opportunities relating to efficiency while solar efforts have focussed on solar technology components, systems and design concepts. BERD performs engineering and architectural research which supports the activities in other program areas. Special coordination task forces exist in the areas of heat pumps, materials, heat engines and wood combustion to ensure coordination and prevent duplication. The thrust of most BERD programs is to conduct R&D which is long term, high risk, costly and therefore not likely to be undertaken by private sector. However, tax credits and/or rebates could be alternative incentives to promote the utilization of those energy efficient appliances not presently included in the residential energy or solar tax credit programs.

PROGRAM IMPACTS:

BERD R&D programs have been the basis for efforts in regulatory and outreach activities. R&D projects have been aimed at working with the private, state, and local sectors to document fundamental understandings of (a) how energy services are achieved in urban areas, (b) how energy flows through a building structure, (c) what effects conservation techniques have on indoor air quality (this defines the limits of conservation applications), (d) which advanced technologies can lead to gas and oil fired space heating systems with conservation efficiencies above 90%, heat pumps with efficiencies ranging from 120% to 150%, and water heaters over 70%; (e) which heating systems can improve operating efficiencies between 20% and 40% of 1975 levels and (f) why energy efficient products are not being more widely offered and purchased by the consuming public. In finding answers to these basic questions, BERD has developed and made available for use by the private sector (a) computer models

to simulate energy use and air infiltration (b) procedures to measure building energy performance (e.g., infrared diagnostics), (c) techniques to aid in the design of more energy efficient buildings, and (d) analytical procedures such as cost/benefit analysis for use in determining qualified conservation techniques for tax credits and applications in Federal buildings.

In the historial context, regulatory requirements met include the following: issuing proposed building energy performance standards (BEPS), proposed appliance standards, residential conservation service (RCS) guidelines, proposed and final appliance test procedures, and proposed life cycle costing guidelines for Federal buildings.

Cost shared R&D has resulted in the introduction into the product market of two new efficient boilers (wood, oil), a furnace efficiency meter, a power gas burner, two new efficient appliances (Refrigerator-Freezer, heat pump water heater) and two lighting products (lamps, solid state ballasts). In the case of the two new efficient appliances, cost shared R&D has resulted in the introduction of refrigators/freezers that are 50% more efficient, and heat pump water heaters that are 120% more efficient. In the case of the two lighting products, R&D efforts have resulted in the introduction of solid state ballast lamps that are 25% more efficient than those currently available, and lamps that will be introduced into the market place within the near future that will be 300% more efficient than the incandescent lamps currently available. Based on sales of these products about 35,000 barrels of oil equivalent have already been saved and as these products saturate the market, additional savings will accrue. By mid 1982 four additional energy efficient product components (air atomized oil burner, ultrasonic oil burner, appliance compressor and a compact incandescent lamp) will be introduced as a result of R&D efforts. Basically, these R&D efforts reduced the cost or perceived risk of producing these products to industry to the point where investment decisions could be made. In addition, technological successes have been achieved with the Stirling Engine freon compressors for gas fired heat pumps, the development of durable materials for use in the corrosive environment of condensing furnaces and the measurement of the thermal capacities of materials and components of building systems.

Information and demonstration program accomplishments have resulted in at least 2.5 million barrels of oil equivalent saved to date under just the Fuel Oil Marketing and Low Cost/No Cost (LC/NC) programs. The Fuel Oil Marketing program is aimed at encouraging consumers to reduce the consumption of No. 2 fuel oil in residential oil fired furnances/burners. The LC/NC program was developed to encourage residential energy conservation actions that would save up to 25% of energy use with an overall $100 investment. At least one faculty member in 92 of the 98 Schools of Architecture in the nation have attended BERD's Seminar on Energy Efficient Design Practices held annually at MIT. About 50,000 professional Real Estate Appraisers have received training to incorporate energy efficiency considerations into the property valuation process under a course principally designed by BERD and delivered by the two major Appraisal Training Organizations. Three hundred thousand energy cost reduction handbooks for 18 types of small businesses have been developed by BERD and distributed to small business through their trade organizations.

Under the RCS program, 46 states and many unregulated utilities have participated, by providing energy audits to their residential customers.

Accomplishments in the area of community systems have also contributed to the achievement of original program objectives under Operation Powerplay, an energy cooperative peak load management program aimed at leveling energy use during peak demand periods through the cooperative efforts of government, commercial business, and industry. There are presently three cooperative programs underway. Furthermore, under the Federal Energy Management Program (FEMP) a 12 percent reduction in energy consumption in Federal buildings has accrued between 1979 and 1980. Grants for 92 energy impacted areas in 24 states have been awarded. Case studies on various energy issues in 18 communities have been completed. Investment decisions on at least two district heating systems resulted from BERD participation. Also, the technical capability developed for these and other efforts is now supporting a HUD grant program for cites to determine their respective district heating possibilities.

Beneficiaries of the BERD program are primarily residential and commercial building owners and consumers who are the indirect recipients of the benefits of building and community energy research programs. Reports and technical data have been released to building trade associations, architects, engineers, builders, equipment manufacturers, financial institutions and state and local governments engaged in energy code adoption and enforcement. Work is continuing on the development and implementation of an improved model building code for state and local jurisdictions. This code will assist builders, designers and code officials to comply with building codes and standards.

Health and safety issues include potential threats to indoor air quality as buildings are made thermally tighter. The increased use of chloroflorocarbon (CFC) as an insulator or refrigerant has potential for eroding the ozone layer. In addition, new indoor lighting products have potentially harmful effects through the wave length they emit and their mercury usage. Overall, however, there will be a large benefit in terms of environmental effects through reductions in the use of energy. Conservation of energy reduces particulate emmissions in the production and conversion of energy. It also reduces the need to import oil and to build new coal and nuclear powered electricity generating capacity.

The objectives of Congress in supporting BERD have been met through accomplishments of the program in fiscal years 1978 through 1981. As described above and on Table 1, R&D, information and demonstration programs are responsible for accelerating the process of building energy efficiency by about 6 years and accelerating the introduction of several key advanced equipment technologies by about 5 years. In addition, many technical reports and documents have been developed which will enable local communities, design professionals, consumers and businesses to conserve energy now and in the future. The cumulative impacts of past investments from BERD funded programs are becoming apparent as the outcomes from R&D efforts begin to deliver the next generation of energy efficient buildings and products, and as communities begin to realize the benefits of energy management activities.

BERD has not met all statutory deadlines for its major regulatory programs, however, and Congress has passed amendments to extent the schedules for the buildings and appliance standards programs.

PROJECTED PROGRAM REQUIREMENTS:

Future BERD Program activities will focus on research and development activities to enhance the private sector's technical options for increasing the energy efficiency of buildings and appliances.

In FY 1982, $27.4 million has been budgeted for BERD. This will be used to fund research in the areas of building envelope systems, ventilation controls, performance calculation, test procedures for appliances, and R&D for advanced appliance technologies. R&D will also focus on the development of advanced technologies for upgrading the energy efficiency of existing district heating systems through new piping materials, lower temperature hot water designs and the "in situ" treatment of installed piping materials. Also, completion of the 10-year Federal buildings' plan will facilitate coordination of energy conservation activities throughout all Federal agencies. No specific budget authority is requested for appliance standards, building standards, RCS, energy impact assistance or demonstration programs.

Continuation of funding at a level of $6.8 million is requested for FY 1983 through FY 1988 in order to achieve current goals.

At a budget level of 10 percent less than that requested for FY 1983, R&D objectives for building systems and materials will be delayed by at least one year. At a budget level 10 percent higher than that requested, assessment of advanced technologies for community energy delivery systems would be accelerated by two years.

DISCONTINUATION REQUIREMENTS:

There are currently legislative mandates for regulatory assessment of Appliance Standards, Buildings Energy Performance Standards, appliance test procedures and the FEMP program. Discontinuation of funding for these activities would mean these legislative requirements would not be met.

Contracts closeout costs to terminate all BERD Programs in FY83 are estimated at $1.9 million.

10/6/81

URBAN WASTE

PROGRAM OBJECTIVES

The goal of the Urban Waste Program is to achieve the production or conservation of 25,000 barrels of oil equivalent per day (BOED) by 1985 through increased use of municipal waste as a source of energy and materials and by improving the efficiency of water and wastewater processing technologies. The Urban Waste Program seeks to resolve technical, economic, institutional, and environmental problems impeding the greater participation of the private sector.

The Urban Waste Program was developed in response to several legislative mandates. The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) authorized the advancement of energy conservation technologies including the use of garbage and sewage, and the reuse and recycling of materials and consumer products. The Department of Energy Act of 1978-Civilian Application (P.L. 95-238) assured adequate Federal support to demonstrate municipal waste processing for the production of fuel and energy intensive products. It also authorized the gathering of information about the technological, economic, environmental and social costs, benefits and impacts of demonstration facilities. The Energy Security Act of 1980 (P.L. 69-294) sought to encourage private capital investment and foster competition. It also established the Office of Energy from Municipal Waste to perform research, development, demonstration and commercialization activities and report on barriers to the development and application of technologies for recovery of energy from municipal waste. The Department of the Interior and Related Agencies Appropriations for 1980 (P.L. 96-126) authorized the Office to support alternate fuels production by monitoring projects selected by the Alternate Fuels Evaluation Board.

The historical objectives of the Urban Waste Program for meeting the Congressional mandates have been to conduct research and development of waste-to-energy technologies; demonstrate waste-to-energy technologies; assess and disseminate technical and economic cost information; provide financial assistance in the form of price support loans, loan guarantees; and support alternate fuels production by monitoring projects under the Alternate Fuels Commercialization Program (See Table I).

The current goal of the Urban Waste Program is to accomplish the long-term generic research and development that is not being accomplished by the small and fragmented waste-to-energy and wastewater treatment industry and which is not addressed by EPA which funds construction of such facilities, not R&D. Research and development efforts will be focused upon the technical and economic improvements of biological, thermal, mechanical, and environmental control technology systems. Efforts are necessary to develop technologies to provide storable and universally usable energy products from solid waste, to develop small-scale systems and to develop energy-efficient equipment for water and wastewater treatment systems. Alternative methods for accomplishing these objectives include enacting changes to the IRS Code, relaxing air pollution standards, and enforcing existing landfill standards.

PROGRAM IMPACTS

The original objectives of the Urban Waste Program are being met as evidenced by the activities described in Table 1. During FY 1978-FY 1981, forty-two technologies (24 biological, 12 thermal, and 6 mechanical) were investigated to improve systems economic, technical and environmental performance. Sixty-six technical reports were published and disseminated to the general public as well as to over 150 municipalities, 56 research institutions, 29 trade associations, 51 interest groups and 400 engineering consulting firms. Of the 25 feasibility studies initiated in FY 1978, 20 resulted in projects which are proceeding to construction. DOE invested just over $7 million and was able to leverage the investment of over $1 billion in private capital for the 20 projects which are estimated to provide 15,000 BOED (60% of the 1985 program goal). The 16 projects being monitored by the Urban Waste Program under P.L. 96-126, Alternate Fuel Program, are anticipated to provide an additional 8500 BOED when carried to completion. A study was initiated in FY 1981 to resolve the institutional, socioeconomic, and legal issues impeding the development of waste-to-energy facilities. The report is to be delivered to Congress in FY 1982 in accordance with the Energy Security Act of 1980. Program rules were established for loan guarantees and were proposed for price support loans. However, appropriations for financial incentives have been rescinded.

The primary beneficiaries served by the Urban Waste Program have been local governments and industry. Localities have benefited from energy production, resale of recovered materials, employment generated by these labor-intensive facilities, and reduced landfill pollution. Over 70 municipalities received financial assistance for feasibility and implementation studies during FY 1978-FY 1981. Industry, the primary party for designing and constructing the urban waste facility, has benefited from the Urban Waste Program by obtaining necessary technical information and know-how from government sponsored R&D, and from workshops, seminars, and other information transfer activities.

The most notable environmental benefits of the Urban Waste Program include the reduction of air pollutants and the mitigation of ground and surface water pollution due to the reduction of landfilling. Reduction in landfill use will also mitigate the potential for fires, explosions, and dust emissions normally associated with such sites.

PROJECT PROGRAM REQUIREMENTS

Funds for FY 1983 have not been requested.

DISCONTINUATION REQUIREMENTS:

The orderly termination of the program will cost $9,820,000. Approximately $720,000 will be required for administrative functions. Requirements for accomplishing activities in the biological, thermal, mechanical and system integration areas will require $1.5M, $3.0M, $1.6M, and $3.0M, respectively.

TABLE 1

BUILDINGS AND COMMUNITY SYSTEMS

PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ Millions) FY 78 $63.45	FY 79 $79.33	FY 80 $103.41	STATUS FY 81 $62.0	DEGREE ORIGINAL OBJECTIVE MET
BUILDINGS ENERGY RESEARCH & DEVELOPMENT						
o To reduce energy consumption by 30% in new buildings by 1985 (from 1978 levels). o To reduce energy consumption by 20% in existing buildings by 1985 (from 1978 levels).	No duplication because research efforts are coordinated with program efforts of Passive & Solar Energy and ECUT programs.	o Began research on Air infiltration, ventilation & existing buildings energy performance. o Issued ANOPR for BEPS. o Redesigned 168 commercial buildings to maximize energy efficiency.	o Issued regulatory & economic analyses & NOPR for BEPS. o 2/3 energy savings in prototype retrofit home. o Lab test facility for HVAC program. o Held conferences, & public meetings for BEPS response.	o Developed energy use models. o Simplified residential model to predict air infiltration rates. o Retrofit 100 homes in New Jersey.	o Developed draft changes to ASHRAE standards with 40% more efficiency. o Completed hand-held energy calculator for home builders. o Life-cycle cost analysis for mobile homes.	o Accelerated process of building energy efficiency by an estimated minimum of 6 years so far. The redesigns provided private sector with the foundation and information to build more energy efficient bldgs.
o To reduce energy consumption of new building equipment by 30% by 1985 (from 1978 levels).	No duplications - Task forces exist to coordinate building	o 47 reports published. o Technological feasibility of steam system demonstrated. o 12% savings of mixed refrigerants shown.	o 42 reports published. o Completed tests on new heat pumps, water heaters, & refrigeration systems.	o 36 reports. o Manufactured high-efficiency wood-fired boiler & heat pump water heater. o Testing of 2nd generation steam engines & heat pumps.	o 51 reports published. o Commercialized high-efficiency refrigerator-freezer, motor-compressor, light bulbs, power gas burner, & engine heat pump.	Introduction of these new technologies accelerated by 5 years. Actual energy savings will increase dramatically in in next several years as production volume increases.

TABLE 1, continued

BUILDINGS AND COMMUNITY SYSTEMS

PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ Millions) / STATUS FY 78	FY 79	FY 80	FY 81	PROGRAM ORIGINAL OBJECTIVE MET
BUILDINGS ENERGY RESEARCH & DEVELOPMENT						
• To develop more efficient community energy delivery systems, to assist communities and small business with energy management and to provide communities undergoing rapid energy development with supplemental financial assistance.	No duplications.	Prototype Operation Powerplay co-op project begun in Los Angeles.	• 1st operational power co-op begun by Southern California Edison. • 56 planning & 76 site acquisition/development Energy Impact Assistance grants made.	• 79 planning & 155 site acquisition/development EIA grants made.	• 2 more Operation Powerplay co-op in operation. • 25 planning & 75 site acquisition and development EIA grant made.	• 92 energy-impacted areas in 34 states approved. • Reference guidebook for community energy management completed. • 6 case study projects on role of energy savings in planning development projects completed. • 8 communities have studied barriers to energy efficiency. • 12 case studies on energy-community issues. • State-of-the-art study completed on energy supply and system planning. • 18 guidebooks on energy cost reduction in small businesses published. • Comprehensive list of energy conserving technologies available to small businesses prepared.
• To reduce, between 1978 and 1985, the average energy consumption in existing Federal buildings by 20% and in new Federal buildings by 45%, by providing technical assistance & monitoring Federal building plans.	None.		Decrease in Federal agency energy use by 5.3% from 1975 level.	Decrease in Federal agency energy use by 6.4% from 1975 level.	Completion of 10-year Federal building plan.	Twelve percent reduction in Federal government energy consumption since 1980.

TABLE 2
BUILDINGS AND COMMUNITY SYSTEMS
CURRENT PROGRAM OBJECTIVES AND BUDGET
(Budget data in FY 82 dollars; millions)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS (for objective target date)	BUDGET JUSTIFICATION AND SERVICES PROVIDED
BUILDING SYSTEMS			
o Advance the understanding of static and dynamic energy performance of buildings through long-term research. o Develop advanced models for evaluating dynamic energy performance in buildings for use by researchers, designers and builders. o Develop and/or test four strategies for improving buildings energy efficiency.	This program element only funds long-term generic research which would not be undertaken by the private sector. Therefore, the free market is not a viable alternative.	Continued funding through the 1980's at the present level of 13.9 adjusted for inflation in areas of Envelope System, Ventilation & Controls, Performance calculations & diagnostics, and Pilot projects and case studies	Budget FY 1982 $13.9 FY 1983 $13.65 Estimated Outyear Costs Private sector cannot undertake long-term generic research, done in this program for the following reasons: (1) structure - size of the buildings industry, (2) risk aversion, (3) competion, (4) slow market penetration of technical advancements.
BUILDING EQUIPMENT:			
o Develop and characterize the underlying technical basis for improving the efficiency of oil and gas combustion heating systems to 0.95, 1.25, and 1.50 by 1986, 1988, and 2000 respectively; of electric heat pumps and refrigeration systems by 40% by 1992, and of lighting systems by 50% BY 2000.	o Incentive to business for research. Targeting these incentives directly to technology advancement may be difficult. Regulations on standards are effective only in the low-efficiency end of the product spectrum.	Further testing and improved design to reduce energy losses.	
o Provide technical support to the FTC labelling program in the area of development and modification of appliance test procedures for all covered products.	o No federal action: no incentive to make high-efficiency products.	Further test procedure development and modification.	Budget FY 1982 $600k

TABLE 2, continued
BUILDINGS AND COMMUNITY SYSTEMS
CURRENT PROGRAM OBJECTIVES AND BUDGET
(Budget data in FY 82 dollars; millions)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS (for objective target date)	BUDGET JUSTIFICATION AND SERVICES PROVIDED
BUILDING SYSTEMS			
Ensure that useful technical information derived from Federal and private sector energy conservation research efforts is made available to the building services industry, and monitor the implementation of the RCS program.	o Reliance on other private enterprise and activities. o Enhanced incentives grants, tax credits, subsidized loans. o Voluntary rather than mandatory participation by utilities o All require Congressional action.	Receipt of adequate budget authority for for Federal standby, utility supply installation, financing, RCS/CACS, autifor training, and technical assistance.	No additional budget authority has been sought for the RCS program in FY 1982.
FEDERAL ENERGY MANAGEMENT PROGRAM			
Monitor Federal Agency energy plans and develop the Federal 10-year energy plans.	o Other Office or agency could administer but program would remain the same.	o Receipt of adequate budget authority. o Receipt of agency 10-year energy efficiency plans for Federal buildings.	Budget FY 1982 $1.0 FY 1983 $1.00 Estimated Outyear Costs $4.9 Co-ordination of energy efficiency and energy conservation activities throughout the Federal governments.

TABLE I

URBAN WASTE PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($Millions) STATUS FY78	FY79	FY80	FY81	DEGREE ORIGINAL OBJECTIVE MET
		$11.00	$13.75	$13.66	$6.88	
Goal: to achieve the production or conservation of 25,000 BOED by 1985 through increased use of municipal waste as a source of energy and materials and by improving the efficiency of water and wastewater processing technologies. Specific objectives are to: o Conduct R&D of waste-to-energy technologies (P.L. 95-238) o Assess and disseminate technical and economic cost information (P.L. 95-238) o Demonstrate waste-to-energy technologies (P.L. 95-238) o Provide financial assistance in the form of price support loans, loan guarantees (P.L. 96-294, P.L. 95-238) o Support alternate fuels production by monitoring projects (P.L. 96-126)		Continued research on RefCOM project Performed research on thermal, biological, and mechanical systems Performed R&D on landfill gas recovery Initiated development of the anaerobic upward flow-ing digestor process (AMFLOW) Performed research on converting sludge to energy Initiated 25 feasibility studies Developed small scale systems plan Held first annual methane recovery and project financing workshops	R&D initiated on 2 mechanical separation projects (TROMMEL and Air Classification) RefCOM facility at Pompano Beach completed startup Pilot scale test completed for AMFLOW Tested 2 thermal systems (pyrolysis) and fluidized bed combustion TORRAX pyrolysis system design at Disney World; continued support for advanced waste treatment project Enzymatic hydrolysis research at U.S. Army Natick R&D Command Methane recovery films and workshops	Initiated construction of AMFLOW anaerobic digestion facility RefCOM operated at initial test conditions Continued enzymatic hydrolysis research at U.S. Army Natick R&D Command Energy user and methane recovery workshops; risk analysis and 2 wastewater conferences	Construction of AMFLOW facility completed Completed evaluation of TROMMEL screens Development of large scale calorimeter Phase I report on RDF preparation and combustion Completed 25 feasibility studies Initiated report to Congress identifying institutional barriers Held conferences on European waste-to-energy technology, refuse derived fuels and wastewater treatment; sponsored 4 regional workshops on PURPA and an energy user workshop	42 technologies were investigated to improve systems economic, technical and environmental performance 25 technologies were demonstrated and will eventually displace 15,000 BOED (60% of the 1985 goal) 66 technical reports were published and disseminated to over 150 municipalities, 56 research institutions, 29 trade associations, 51 interest groups, and 400 engineering consulting firms 16 projects concerning waste-to-energy systems are currently being monitored under the Alternate Fuels Commercialization Program Over $7 million leveraged the investment of over $1 billion in private capital for 20 projects which are proceeding to construction Institutional, socio-economic and legal barriers study initiated; report to be delivered to Congress in FY 1982 Appropriation for accelerated commercialization rescinded

OCT 5 1981

SUNSET REPORT

PROGRAM: INDUSTRIAL ENERGY CONSERVATION

ADMINISTRATOR: ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

PROGRAM OBJECTIVES:

The Industrial Energy Conservation Program consisted of research, development and demonstration of new high risk, high potential industrial energy conservation technologies; stimulation of use for existing but underutilized technologies; the Industrial Reporting Program; and dissemination of technical information to end users in the private sector.

The Program was developed in response to a variety of enabling legislation mandating its various elements as follows:

LEGISLATION	SPECIFIC LANGUAGE
P.L. 93-577, Federal Nonnuclear Energy Research and Development Act of 1974 Section 4, Paragraph b, Section 4, Paragraph c	"...Formulate and carryout a comprehensive Federal nonnuclear energy research, development and demonstration program."
	"...By initiating--programs--utilizing facilities, capabilities, expertise and experience of--industrial entities--which are appropriate..."
P.L. 94-163, Energy Policy and Conservation Act Title III, Part E	"...Establish voluntary energy efficiency improvement targets..." (for the most energy intensive industries).
	"...Prepare--an annual report..."
P.L. 95-91, Department of Energy Organization Act Title II, Section 203, Part 9	"...Functions--include--implementation of major research and demonstration programs for the development of technologies and processes to reduce total energy consumption." (Including industry.)
P.L. 96-294, Energy Security Act Title V, Subtitle G, Section 591	"To accelerate the research, development and demonstration of energy conserving activities designed to substantially increase productivity in industry, there is authorized to be appropriated...for Industrial Energy Conservation... the sum of $40,000,000 for each of fiscal years... ending...on September 30, 1982."

The industrial sector consumes about 37 percent of the total energy in the United States, mostly from scarce oil and natural gas. The energy end-use efficiency in the industrial sector is generally low since the industrial complex (of over 460,000 manufacturing, construction and agricultural firms with capital stock of over $750 billion) was established during several decades of abundant and low cost energy. Industry has achieved, and should continue to achieve significant energy savings on its own and over the past 10 years has averaged a little over 1 percent.

decrease in energy consumption per unit of output per year. Industry, on its own, has implemented existing, proven energy conservation technology involving low risk and moderate to high payoff when capital was available after higher priority investments were completed. However, the private sector was reluctant to pursue high risk energy conservation technologies on its own in a timely fashion because of a variety of reasons which vary from industry to industry. These include high technical and financial risk; availability of and higher priority demands for available capital; relatively low ratio of energy-to-product cost and costs easily passed through in product pricing; and lack of proven technology options and technical expertise.

The historic goals of the Industrial Energy Conservation Program have been to cost-share research, development and demonstration in order to increase the technology options commercially available to industry and agriculture for improving the energy efficiency of processes, reducing the amount of waste energy and substitution of more abundant fuels for scarce fuels; to achieve incremental annual energy savings of 1.0 quad (reduced from 1.5 in FY 1980 due to budget restrictions) by 1985 and 5.5 quads by 2000 from industrial investment in the technologies supported by DOE; and to transfer information on the costs and benefits of technologies developed. The current goal is the orderly termination of the program at the end of FY 1982.

The objectives related to achieving the historic program goals have been to:

- o Cost-share research, development and demonstration support for industrial industrial energy conservation technologies having large potential for saving scarce fuels, and encourage the implementation and deployment of developed and/or demonstrated technologies by the private sector.

- o Increase industrial awareness of cost-effective energy efficiency improvement technologies, and encourage private sector initiatives which result in the implementation of more energy efficient technologies and practices.

  -Receive, review and analyze annual efficiency improvement reports from 1,000 energy-intensive corporations, and publish five DOE reports to Congress. Establish recovered materials targets for four industries.

  -Publish and disseminate technical reports on underutilized, cost-effective, energy-efficient technologies and practices. Sponsor workshops and seminars to disseminate information on new and underutilized technologies.

  -Publish and distribute to Congress legislatively mandated reports on the applicability of the Second Law of Thermodynamics to energy conservation programs, by November 1979, and the alternatives for improving the energy efficiency of industrial electric motors and pumps, by April 1980.

- o Provide energy audits for small and medium size industrial firms.

  -Through FY 1980, operate three Energy Analysis and Diagnostic Centers (EADC'S), each conducting 40 audits per year.

-During FY 1981, establish and begin operation of three additional EADC'S, for a total of six.

The activities of the program were selected so as not to duplicate developments that the private sector, alone, was pursuing or would be likely to pursue. Specific historical goals and objectives are shown on Table I.

The current objectives are to phase out all projects in the program at the next meaningful milestone during FY 1982 and prepare reports on results to date for the program.

Other programs that have been identified which relate in different ways to the goals of the industrial program are shown on Table I and include the recently organized Energy Conversion and Utilization Technology Program within DOE which is directed at basic and applied R&D; Heat Engineering Branch of Coal Utilization which is limited to coal use; cogeneration demonstration programs of the Electric Power Research Institute (EPRI), the industrial conservation demonstration program of the Gas Research Institute (GRI) and major government funded efforts in industrial energy conservation RD&D in Western Europe and Japan.

With the exception of the efforts of foreign countries, there is no overlap of activities in the various efforts relating to Industrial Energy Conservation. To the contrary, the close integration and regular communications between the Office of Industrial Programs and the other organizations ensures nonredundant and complementary efforts.

Alternative programs to achieve program goals, include: (1) reliance on the private sector in conjunction with the Administration's program for economic recovery; (2) increased tax credits for energy conservation investments (These alternatives would address the program goals through increased use of existing, proven technologies); and (3) tax credits for Industrial Conservation R&D.

PROGRAM IMPACTS

The historical goals and objectives as shown on Table I are being achieved to a significant degree. This is evidenced by the support of 165 new, high risk technology developments to date of which eight early starts are already penetrating the market and saving 6.51 trillion Btu's per year. Information and results of technical innovations have been widely disseminated through 24 workshops and seminars having over 6000 attendees and over 31,000 recipients of descriptive technical brochures. Small to medium sized concerns have been assisted by a total of 359 audits conducted in their facilities through the Energy Analysis and Diagnostic Centers. The progress of the industrial sector in industrial conservation has been monitored via 935 companies who report on efficiency improvements and through 48 trade associations. The following paragraphs briefly address specific accomplishments to date.

Energy Conservation in Coil Coating: A unique method whereby the paint solvents are trapped in the curing process and used as fuel to fire the curing ovens was developed and tested. This technology can reduce the natural gas required for coating coils by as much as 80 percent and is fully developed and is rapidly penetrating the marketplace with no further Federal support. Twenty-three installations of the technology are in place and achieving energy savings approaching 3.5 trillion Btu's per year. The initial Federal investment was $412,000 of which $216;000 was paid back to the government after the successful demonstration.

Plastic Waste to Fuel Oil: The Industrial Program successfully developed a process to turn waste polypropylene plastic into the equivalent of distillate fuel oil. Presently, one such plant is on-line and producing 300 billion Btu's (i.e., two million gallons) per year of fuel oil. The total potential production of this technology is estimated to be almost 0.02 quad per year. The Federal investment was $442,000.

Textile Foam Finishing: The program has developed a method of finishing fabrics utilizing a foam rather than an aqueous process. This causes a considerable decrease in the energy required to dry the fabric. The technology for textile foam finishing is fully developed and beginning to penetrate the market. Eighteen textile foam processing systems are in place processing over a billion yards per year and presently saving an estimated 279 billion Btu's per year. This foam processing technology is also being developed for dyeing, printing, and the preparation of fabrics and is only now starting to penetrate the market place. The total estimated potential for this technology is 58 trillion Btu's per year or 10 million barrels of oil equivalent. The total Federal cost was $662,000.

Granulated Fertilizer Production: A new process, utilizing pipe-cross reactors, was developed by the DOE Office of Industrial Programs and introduced to the ammoniation-granulation sector of the industry, has the potential to save 100 percent of the energy used for process steam and 80 percent of the energy used for drying. This technology is fully developed and beginning to penetrate the market; twenty-eight installations are in-place and operating. These units are presently saving 1.2 trillion Btu's per year. The total potential savings for this technology is estimated to be almost 30 trillion Btu's per year or 5 million barrels of oil equivalent. The total Federal cost was $540,000.

Efficient Slot Forge Furnace: A new, high efficiency slot forge furnace has been developed. Not only does the new furnace improve the operating efficiency to almost 40 percent, but it can burn residual oil instead of distillate. This technology is fully developed and rapidly penetrating the marketplace. Thirty units are in operation and achieving estimated energy savings of 600 billion Btu's per year. The total potential savings for this technology is 12 trillion Btu's per year or two million barrels of oil equivalent. The total Federal cost was $1,900,000.

criteria including those where "it is unlikely that similar results would be achieved in a timely manner in the absence of Federal assistance," "the degree of risk of loss of investment inherent in the research is high" and "...the investment appears to exceed the financial capabilities of potential non-Federal participants in the research." Briefly paraphrased the Congressional intent was to affect conservation of energy which would not likely be accomplished without Federal involvement.

The Industrial Energy Conservation has carefully followed these principles to meet the objectives of Congress in establishing the program of "research, development and demonstration" and "establish voluntary energy efficiency improvement targets." A program of RD&D was established by carefully selecting over 165 activities of high risk research, development and demonstration which the private sector was unlikely to pursue alone. A total of eight projects started earlier have been completed and are already penetrating the market and having a current annual energy savings of 6.51 trillion Btu's. Although it is too early to state that the objectives of Congress have been met, the facts that eight projects are already entering the market and having significant tangible savings and the existence of over 150 other RD&D activities in various phases of development clearly indicates that the objectives of Congress are being met.

During the four years (FY 1978-1981) the appropriated budget grew from $29.55 million to $89.7 million and the cumulative authorizations were $172.8 million. During this period, steadily increasing commensurate with budget appropriations were numbers of R&D projects, reports published, workshops conducted, and energy audits conducted as well as significant market penetrations for technologies successfully developed and tested. Stated simply, the program "came of age" during this period and reached the point where several early starts were already paying off and a wide band of technologies were in various stages of development aimed at continually deepening and broadening the impact.

PROJECTED PROGRAM REQUIREMENTS

The program budget request for FY 1982 is $965,000 for Program Direction to terminate the activities. Although the program was successful in the past, it is the view of the Reagan Administration that further activities of this type will be accomplished by the private sector without Federal involvement.

DISCONTINUATION REQUIREMENTS

The program is planned for termination in FY 1982 and would therefore have no further requirements in FY 1983.

TABLE

INDUSTRIAL ENERGY CONSERVATION

PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	BUDGET DATA ($MILLIONS) STATUS FY 78	FY 79	FY 80	FY 81	DOCREE ORIGINAL OBJECTIVE MET THROUGH FY 1981
		$29.6	$40.0	$60.2	$89.7 APPROPRIATED $43.0 AS RESCINDED/ DEFERRED	
.Goals: to cost-share research, development and demonstration in order to increase the technology options commercially available to industry and agriculture for improving the energy efficiency of processes, reducing the amount of waste energy and substitution of more abundant fuels for scarce fuels. To achieve incremental annual energy savings of 1.0 quad by 1985 from industrial investment in the technologies supported by DOE. To transfer information on the costs & benefits of technologies developed. -Cost-share research development & demonstration support for industrial energy conservation technologies having large potential for saving scarce fuels, & encourage the implementation and deployment of developed and/or demonstrated technologies by the private sector.	.Energy Conversion and Utilization Technology program. .Western Europe & Japan RD&D. .Gas Research Institute (GRI) & Electric Power Research Institute (EPRI) RD&D. .Heat Engineering Branch of Coal Utilization.	.Cogeneration activity began. .Test air/fuel ratio control. .Feasibility test of waste oil rerefining. .Complete designs for 3 heat pumps. .77 technologies supported. .Complete designs for 5 recuperators. .Complete design of foam finishing system. .Demo complete on fumes-as-fuel & 2 units on-line. .Complete study of polypropylene conversion. .Complete preliminary test on slot forge.	.Complete study on waste tire conversion. .Complete oil-fired air/fuel ratio control test. .Design O_2 enrichment demo. .Develop alternatively powered hand tools. .Pilot test/inert cathode. .Start coal in aluminum remelt. .104 technologies supported. .Complete demo's of 5 ceramic recuperators. .Complete fabrication of foam finishing demo. .8 fumes-as-fuel on-line. .Complete pilot demo of polypropylene conversion .First pipe-cross reactor test. .2 slot forges on-line.	.Fabrication of O_2 enrich. demo's. .Initiate 2 projects for waste tire conversion. .Demo/metallic recuperator. .Initiate hot inspection project. .Start inert anode development. .150 technologies supported. .12 recuperators on line. .Complete foam finishing demo & 9 units on-line. .15 fumes-as-fuel on-line. .One full size polypropylene plant on-line. .12 pipe-cross reactors in operation. .15 slot forges on-line.	.National Academy of Science overview completed. .Heat pump grain dryer demo. .Waste lube oil recovery demo. .3 cogeneration units fab.	.A total of 165 new technologies have been supported to date. .Number of new technologies completed through FY 1981: 8 .Number of installations of new technologies through FY 1981: 162 .Actual incremental annual energy savings to date from new technologies: 6.51 trillion .Actual incremental annual savings from new energy substitution technologies: 36 trillion .Recuperators on line: 34 .Foam finishing installed: 18 .Fumes-as-fuel on-line: 23 .Polypropylene waste conversions: 1 .Pipe cross reactors on-line: 28 .New slot forges used: 30

TABLE I
INDUSTRIAL ENERGY CONSERVATION
PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	BUDGET DATA ($MILLIONS) STATUS				DEGREE ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	THROUGH FY 1981
		$29.6	$40.0	$60.2	$89.7 APPROPRIATED $43.0 AS RESCINDED/ DEFERRED	
			.Crop residue-fired grain dryer tested.	.Energy Integrated Farm contracts awarded. .First full assembly line operating with hi. eff. hand tools.		.Waste-fired grain dryers: 28
.Increase industrial awareness of cost-effective energy efficiency improvement technologies, & encourage private sector initiatives which result in more energy efficient technologies & practices. -Receive, review & analyze annual efficiency improvement reports from 1,000 energy-intensive corporations, & publish 5 DOE reports to Congress. Establish recovered materials targets for 4 industries.						.Companies reporting: 935 .Trade associations contacted: 48 .Contractors: 240 .Number of corporations reporting: .93% .DOE reports on industrial energy efficiency improvement. .Recovered materials targets were established.

TABLE I
INDUSTRIAL ENERGY CONSERVATION
PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	BUDGET DATA ($MILLIONS) STATUS FY 78	FY 79	FY 80	FY 81	DEGREE OF ANNUAL OBJECTIVE MET THROUGH FY 1981
		$29.6	$40.0	$60.2	$89.7 APPROPRIATED $43.0 AS RESCINDED/ DEFERRED	
-Publish and disseminate technical reports on underutilized, cost-effective, energy efficient technologies & practices. Sponsor workshops & seminars to disseminate information on new & underutilized technologies.						.Number of technologies addressed: .Number of publications disseminated: 31,452 .Number of workshops & seminars conducted: 74
-Publish & distribute to Congress legislatively mandated reports on the applicability of the Second Law of Thermodynamics to energy conservation programs, by Nov. 1979, & the laternatives for improving the energy efficiency of industrial electric motors & pumps, by April 1980.		.Conduct workshop on remanufacturing.	.Mandatory and voluntary reporting program integrated. .Targets established for utilization/recovered materials. .Complete 2 technical manuals & 5 brochures. .Start study of feasibility of performance standards on motors and pumps.	.Conduct 10 boiler training workshops in New England. .Complete implementation plans for steel, paper & food.		.Published report on Second Law. .Published report on motors and pumps.
.Provide energy audits for small & medium industrial firms.		.Establish 3 EADC'S. .Conduct 10 audits.	.Continue 3 EADC'S. .Conduct 105 audits.	.Expand to 6 EADC'S. .Conduct 115 audits.	.Continue 6 EADC'S. .Conduct 139 audits.	
-Through FY 1980, operate 3 Energy Analysis & Diagnostic Centers (EADC'S), ea. conducting 40 audits per year.						.Number of EADC'S operating: 6 .Number of audits conducted annually by ea. EADC: 40 .Number of audits conducted through FY 1981: 359

Crop Residue Grain Dryer: There are 36 million tons of cornstalks grown each year in Iowa alone. This is in fact Iowa's largest renewable energy resource. A grain drying furnace that utilizes cornstalks as a fuel source has been developed. There are presently 28 such units in operation using an estimated 60 billion Btu's per year of cornstalk fuel for corn drying. The total Federal cost was $105,000.

High Temperature Recuperators: Recuperation is a primary method of waste heat recovery and reuse and is therefor fertile ground for conservation efforts. For this reason, the Industrial Program has placed considerable emphasis on research and development involving the production of more efficient and useful recuperators. Through the end of FY 1981 thirty-four installations of high temperature ceramic recuperators realizing energy savings of 700 billion Btu's per year were completed.

Energy Analysis and Diagnostic Centers (EADC'S): The program funds six university engineering teams which conduct energy audits and cost benefit analyses for small and medium-sized manufacturing firms. In 1979, when only three of the six centers were in operation, 105 audits were conducted that are presently saving an estimated 350 billion Btu's per year. In total, the 359 audits conducted to date are estimated to be saving approximately one trillion Btu's per year.

The Industrial Energy Conservation program has had a very favorable impact on the national economy by creating new jobs for equipment manufacture, operation and maintenance (a net increase of over 300 new jobs in 1981); reduced costs of U.S. goods (over $20,000,000 in 1981); reduced oil imports; increased productivity; and increased Federal tax revenues from increased corporate profitability. Competition is enhanced by the emphasis on widespread dissemination of the new technologies to all industries. Similarly, the impact on the environment, health and safety have been positive. More efficient use of energy results in reduced air and water emissions in proportion to the energy consumed and increased utilization of waste materials eliminates solid waste disposal problems which include groundwater contamination from disposal sites. Of 186 projects having possible environment and health impacts reviewed in FY 1981 only 17 warranted further assessment. Therefore, over 90 percent of the program activities clearly are beneficial to health and safety and the other 10 percent can be designed so as not to be harmful if assessment indicates a problem. Increased efficiency recovery and reuse of waste heat, recycling of waste rather than land filling and advanced cogeneration of electricity and thermal energy can have significant favorable impact on U.S. health and safety. Since only eight of the projects to date have been completed--and these are having a measurable impact--it is too early to assess quantitatively the impact of the program.

The governing principles of PL 93-577 stated in part that "energy conservation shall be a primary consideration in the design and implementation"..., and that "conservation means both improvement in efficiency of energy...use, and reduction in energy waste." It is further stated that activities selected satisfy

OCT 7 1981

SUNSET - PHASE II

Program: Transportation Programs

Administrator: Assistant Secretary for Conservation and Renewable Energy

PROGRAM OBJECTIVES

The Transportation Program performs R&D on vehicles and engines to increase the fuel efficiency of the transportation system and to allow it to switch from petroleum to electricity and alternative fuels. The original legislative mandate was the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), which directed the Administrator to "advance energy conservation technologies, including...improvements in automobile design for increased efficiency...including investigation of the full range of alternatives to the internal combustion engine...."

Additional acts provided greater focus on specific research and development along with funds for operations. The Automotive Propulsion R&D Act of 1978 (P.L. 95-238) had as its purpose to fund advanced automobile propulsion systems, enhance the competition among existing and alternative automotive propulsion systems, supplement private industry R&D on advanced systems, and give priority attention to those advanced systems with fuel flexibility. This public law provides the rationale for the Vehicle Propulsion program. Congress established this program because it found that domestic vehicle manufacturers were devoting insufficient resources to research and development on advanced propulsion systems that would have their benefits realized only in the long-run.

The Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976 (P.L. 94-413 as amended by P.L. 95-238) declared that the policy of Congress was to encourage and support accelerated research of electric and hybrid technologies, demonstrate the economic and technical practicability of electric and hybrid behicles (EHVs), and remove barriers to the use of EHVs. This public law provides the justification for the Electric and Hybrid Vehicle RDT&E program.

The Transportation System Utilization (TSU) program is made up of several components, each of which has the support of a public law. The production and distribution of an automobile fuel economy guide is mandated by Section 506(b) in P.L. 94-163 (1975). The promotion of voluntary and mandatory conservation programs was stated as a policy by Section 5(b) in P.L. 93-275 (1974). The development of a standby conservation plan and of state gasoline consumption targets were mandated by Section 212(a) in P.L. 96-102 (1979). The Alternative Fuels Utilization (AFU) program had legislative backing from Section 101(c) in P.L. 95-238 (1978) and the Methane Transportation R&D and D Act of 1980 (P.L. 96-512).

The transportation sector accounts for over half of the U.S. petroleum consumption and is itself almost entirely dependent upon petroleum as its fuel source. The National Energy Policy Plan (NEPP) has a midrange projection of 9 MBPD of petroleum use by the transportation sector in the year 2000. It is possible, with cost-effective technology improvements, fuel substitution, and conservation, to reduce the transportation petroleum use another 25 percent by 2000 from the NEPP baseline.

One goal of Transportation Programs is to conduct R&D that, through cost-effective fuel efficiency improvements and fuel substitution, will assist the Nation in reaching this 25 percent savings potential, while mantaining personal mobility and protecting both human health and safety and the environment.

Another goal is to develop fuel efficient and alternative fuel vehicles that would help provide the Nation with a hedge against an uncertain future with respect to sudden and large petroleum price increases, shortages of petroleum, continued economic difficulty in the U.S. motor vehicle industry, and/or climatic problems from CO_2 that would prevent the expanded use of fossil fuels. There is some chance that any of these four events could occur. The chance that at least one of them will occur is quite high. Therefore, it is in the national interest to have energy saving and non-petroleum using transportation technologies available in reserve that could be drawn on when and if an emergency of unknown duration arises. In this respect, advanced technology and non-petroleum technologies can be viewed as a form of insurance.

The specific objectives of Transportation Programs are depicted in Table 2. Every method possible has been utilized in the past to achieve the goal of reducing transportation petroleum use, but the current and future emphasis will be placed on research and development of generic, high-risk and high-payoff technology that private industry is unable or unwilling to undertake on its own.

Although advanced engine and electric vehicle research is not duplicated in this country, similar programs are underway in Europe and Japan. These foreign programs receive government support and provide a challenge to the U.S. motor vehicle industry that can be met with a cooperative U.S. government/industry R&D program. The only significant U.S. transportation R&D effort aimed at fuel efficiency improvements not conducted by DOE is NASA's $100 M. per year aircraft efficiency program.

With regard to alternative means of accomplishing the goal, the current Transportation Program includes research on all the technology options: materials research that would make all heat engines more efficient, advanced diesel research, alternative heat engines and electric vehicles. With regard to fuel substitution, the Transportation Program includes research on substituting petroleum with electricity (via the electric vehicle) and alternative fuels (via modified conventional engines or advanced heat engines that have greater fuel flexibility).

PROGRAM IMPACTS

The original objectives of the Vehicle Propulsion program were mostly long-run in nature and have not yet been fully achieved, an exception being the demonstration and testing of heavy-duty turbine engines in actual bus service. Through cooperation with Greyhound Corporation for intercity bus service and with the Urban Mass Transit Administration and the Baltimore Mass Transit Administration, DOE placed a number of turbine buses into revenue operation. The desired fuel economy was not achieved, and this demonstrated the need for ceramic parts. The importance of an adequate infrastructure was also revealed by the demonstration project.

With respect to the gas turbine engine, significant progress has been made in materials and aerodynamics in the past few years as a result of DOE's effort. Compressor and turbine efficiencies have been improved several percent and ceramic high temperature materials have been formed into intricate airfoil and rotor shapes that have been successfully tested in an engine environment for the first time. Progress in these technologies will apply also to a number of other commercial and military applications, such as cruise missile engines, small aircraft/helicopter gas turbines, and other rotating machinery. Stirling engine improvement over the last few years has also been significant. The MOD I Stirling engine has shown over a 50 percent improvement in efficiency over its predecessor. Additionally, improvements in seal technology, materials, and hydrogen permeability have increased engine durability and reliability. Results have either met or exceeded the projected values, thus increasing the credibility of the developed computer design programs. The Stirling engine improvements have spin-off benefits for other applications such as solar electric, heat pumps, military ground power units, industrial process energy, and farm power.

The original objectives of the EHV program included the development of a demonstration program. This has been very successful, with 68 cost-sharing site operators using about 1000 electric vehicles as of fall 1981. The demonstration program established a group of EV users who could absorb new vehicles and components as they became available. Another objective of the program was to assist small businesses. This was done by awarding competitive contracts to produce state-of-the-art electric vehicles and establishing a loan guarantee program (as directed by P.L. 94-413). The demonstration program also achieves another objective by stimulating similar demonstration programs at TVA and EPRI. The original objectives have been met, except that the number of demonstration vehicles never reached 10,000 due to inadequate funding.

The 100-mile electric vehicle range for 1984 is substantially above the 30 mile range that existed 1976 and the 1981 range of 70 miles for the ETV-1 test vehicle. Progress was made during the last four years

in stimulating an EV program at General Motors which has stated plans to produce a two-passenger electric vehicle in 1987. These plans have become less certain with the financial difficulties being experienced by GM. The continued DOE program is considered important to keeping the GM plans on track.

The original Transportation System Utilization (TSU) program objectives were numerous and diverse. A few of the major objectives are shown in Table 1. A driver fuel efficiency training course (DECAT) was established in 1978 and by 1981 had instructed over 3000 drivers and more than 500 instructors. A survey of 102 graduates of the DECAT program revealed that most of these respondents had conducted driver efficiency classes and that they planned to train over a thousand instructors who would eventually train over 200,000 drivers.

The Standby Federal Emergency Energy Conservation Plan required by P.L. 96-102 mandated that state gasoline consumption targets be established and contingency plans be developed. Both of these requirements were satisfied on schedule.

The Alternative Fuels Utilization program has as its major objective the optimization of the future interface of new fuels and new or modified engines. The program has been successful in establishing a technology data base with regard to new fuels and in sponsoring regular roundtable forums in which the engine manufacturers and fuel suppliers have participated. Successes in evaluating and testing alcohol fuels have provided a firm foundation of research for use by the new Office of Alcohol Fuels.

In terms of recent changes in program focus, the Voluntary Truck and Bus Program, conducted jointly with the Department of Transportation (DOT), has been dropped by DOE and picked up solely by DOT.

The only TSU program that will continue is the annual publication of the Gas Mileage Guide. This program has produced and distributed 15 million or more guides in each of the last four years. A survey of guide use and impact revealed that about 3 percent of new car buyers (about 300,000 per year) used information in the Guide to select or reject a new vehicle. Furthermore, it was discovered that these buyers purchased a new vehicle that was 2 mpg higher than vehicles purchased by other buyers. Given the lifetime savings of the approximately 300,000 new cars that were 2 mpg more efficient and the cost of producing the Guide, each dollar spent on the Guide saved about 2 barrels of oil.

Demonstration programs are being terminated or phased out for gas turbine buses, electric autos and light trucks, and fleet use of alternative fuels and fuel economy devices. The EHV demonstration program has played an important role in stimulating demonstration programs and/or providing improved vehicles for the Post Office, TVA, and EPRI. There is general agreement that the EV program of DOE has been helpful in sparking Detroit's interest in the electric vehicle.

The ultimate beneficiaries of the program are the users of transportation services and the transportation system: 140 million drivers, thousands

of businesses that ship goods, truckers (over one million), and the Nation, as a whole, which ends up being less dependent on unreliable petroleum sources.

The four U.S. automobile manufacturers have benefited directly through the cost-shared R&D contracts that each of them has had for vehicle propulsion. Likewise, GE-Chrysler and Garrett have benefited directly from their cost-shared R&D on electric vehicles. All the results from these contract efforts have benefited the hundreds of researchers and academics who attend the annual contractor's meetings for both vehicle propulsion and electric vehicles.

The beneficiaries of the outreach program have been numerous. In addition to the 300,000 new car buyers benefited annually by the mileage guide and the 500 driver training instructors, the outreach program has distributed over 6 thousand reproducible "Gas Saver" kits, has shown the movie "Running on Empty" to over 20 million people, and distributed several million copies of "How to Save Gasoline and Money." Many persons have joined vanpools and have benefited directly by DOE's contribution in convincing 47 states to adopt new insurance rates and classifications for vanpools.

A major issue to consider in any transportation conservation program is the impact on personal mobility and on the freight transportation system. Both play pivotal roles in the national economy. About 18 percent of the Nation's Gross National Product is accounted for by the transportation system. Fuel availability and price increase problems have been offset somewhat in the past by conservation efforts (both behavioral and efficiency improvements) and can be offset in the future with the timely introduction of technologies that are fuel efficient and cost-effective.

The aggregate impact of advanced heat engines and/or electric vehicles on the national economy will likely be small in terms of total employment. But the impacts will be positive since it is expected that both of these technologies will benefit domestic vehicle manufacturers and thus improve the balance of trade and create or maintain additional domestic jobs in the automotive and support industries. The cost to consumers will be reduced on a per mile traveled basis because the new technologies will allow each vehicle user greater flexibility to choose a vehicle or vehicle mix which optimizes his or her own travel costs. The utilization of alternative fuels in the transportation sector will increase the use of domestic resources to power vehicles and reduce fuel prices.

Several beneficial environmental consequences could result from successful transportation programs. Substituting electric vehicles for gasoline or diesel using vehicles will reduce the total tonnage of air pollutants, change their mix in a beneficial way, and shift their dispersal away from population centers. In addition, there are benefits available from the use of certain fuels, such as alcohol, due to lower levels of NO_x emissions.

Congressional objectives are being met in both the vehicle propulsion and EHV programs. Advanced automobile propulsion systems have been funded, competition among existing and alternative automotive propulsion systems has been enhanced, advanced, and federal funds have been used to supplement private indsutry R&D. With regard to the EHV program, electric and hybrid research has been accelerated, the current state-of-the-art vehicles have been demonstrated, and some of the barriers for EHV introduction have been removed. The budget expenditures over the last four years are shown in Table 1.

PROJECTED PROGRAM REQUIREMENTS

The current mission of transportation programs is to assist in eliminating the need for imported oil by 2000 and preparing for eventual phase-out of petroleum use in the transportation sector. To do this, the government must fund potentially high payoff technological R&D that is risky and of such a long term nature that private industry will not undertake it alone.

The transportation programs budget request for FY 1982 is $38.3 M and for FY 1983 is $25.7 M. The allocation among the four main programs is as follows:

	FY 1982	FY 1983
Vehicle Propulsion	$11.0 M.	$ 6.4 M.
Electric & Hybrid Vehicles	19.6 M.	17.0 M.
Transportation Systems Utilization	1.0 M.	1.0 M.
Alternative Fuels Utilization	5.4 M.	0 M.
Program Direction	1.3 M.	1.3 M.

Continuation of funding at the FY 1983 level through the 1980's will be required to meet the current program objectives.

With a ten percent higher budget level for FY 1983, work would be undertaken with direct-injection diesel research, micro-processors in engine/transmission control, state-of-charge meters for batteries, battery chargers that would not overcharge and a second printing of the mileage guide. With a ten percent lower budget, the development of ceramic components and the extension of battery range and lifetime will be delayed one year.

DISCONTINUATION REQUIREMENTS

Because of the multi-year nature of some of the research projects (one is over 50 months), sizeable expenditures and a year or more might be required to terminate some contracts. Two types of termination could be considered: termination with sufficient documentation to allow continuation by another party (technology transfer or technology salvage) and termination to minimize dollars expended.

There is also the issue of executive or legislative action that might have to be taken to terminate some research efforts. For example, action would be required by Congress to repeal or amend the Automotive Propulsion Research and Development Act (P.L. 95-238) should the vehicle propulsion program be terminated at the end of FY 1982.

TABLE I

PROGRAM ACCOMPL (HISTORIC)

GOALS/OBJECTIVES	OTHER PROGRAMS	BUDGET EXPENDITURES ($ MILLIONS)/STATUS				DEGREE ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
VEHICLE PROPULSION (P.L. 95-238)						
Develop Advanced Propulsion System Technology		27.5	36.5	40.5	35.6	
• Develop new engines that by 1985 could achieve 30-percent fuel economy improvement over comparable spark ignition engines.	GM Proprietary Turbine Project	23.0 Award Ceramic Applications Contract	29.5 Completed Turbine Concept Design Study	32.9 Complete MOD I	61.5	• Simulated turbine rotor coldspun to 134,000 RPM without failure, exceeding acceptable level.
	Swedish Project on Stirling Engines	Analyze Stirling Oil Dumping Ring Seal	Start MOD I Stirling Design			• Stirling MOD I engine test achieved 36% peak thermal efficiency.
• Test heavy duty turbine engines in local & intercity bus service by 1981.	Conducted jointly with DOT/UMTA for local and Greyhound for intercity	3.6	7.0	7.6	6.4	• Desired fuel economy not achieved due to lack of ceramic components, unacceptable maintenance results from inadequate infrastructure.
• Develop waste heat recovery technology for application to pipeline, marine, rail, and truck use.	None	.3	.2	.2 Pipeline & Marine feasibility completed	.1	• Objective to conduct demonstration in pipeline, marine & rail not achieved. Truck bottoming.
• Identify compatibility of medium speed diesel engines to use off-spec & alternative fuels	None competing	-	0	.1 Run laboratory test engine and locomotive engine for #2 diesel low cetane fuels, synthetics (SRC-20 Paraho), and alcohol mixtures	.2	• End 12% fuel economy improvement for prototype component. • The most promising fuels were identified.
ELECTRIC & HYBRID VEHICLE SYSTEM						• Stimulated GM initial program.
Perform R&D&E on Electric & Hybrid Vehicles (P.L. 94-413)		29.3	37.5	37.0	36.8	• Begin introduction of nickel/iron batteries into 20 vehicles Sept. 1981.
• Introduce, test, and evaluate EVs in fleet operations.	Tentative GM plans to produce 2-passenger urban EV by 1986 or 1987	Promulgate performance and safety standards	"284" delivery 57 demo sites selected	GM cost-sharing site operators	4 EV crash tests performed	• Removed barrier presented by CAFE standards not including EVs.
• Develop Electric Test Vehicle (ETV-1)	Small demo projects at Post Office, TVA, EPRI	5 site operators selected			ETV-1 tested with upgraded batteries ETV-2 tested	• Encourages small EV producers as required by Act.
• Develop Hybrid Test Vehicle (HTV)					Hybrid design completed	• 1000 EVs in operation at 01 sites. (10,000 were required by legislation but not funded.
• Provide loan guarantees		Promulgate loan guarantee regs	13 proposals received	2 loans awarded	1 request disapproved	• Provided $3 M. in commitments to guaranteed loans.
						• Studies and annual reports mandated by Act completed on schedule.
						• Entered into joint agreements with DOT, NASA & DOA as required by Act.
						• Transferred data to industry.

TABLE 7

PROGRAM ACCOMPLISHMENTS (HISTORIC)

GOALS/OBJECTIVES	OTHER PROGRAMS	BUDGET EXPENDITURES ($ MILLIONS)/STATUS				DOE/HQ ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
TRANSPORTATION SYSTEM UTILIZATION						
Provide consumer information and promote voluntary conservation		$3.5	$6.2	$5.2	$4.9	
• Distribute Gas Mileage Guide to all new car dealers (P.L. 94-163)	HPG information printed in consumer stores & journals	$ .8 Added compact size to Guide 16 M printed	$1.0 Added small truck to Guide - 16 M printed	$1.6 Conducted survey of Guide's effectiveness - 17 M printed	$1.8 Analyzed EPA vs. on-road MPG disparity - 15 M printed	• 300,000 auto buyers each year use the Guide to select or reject a vehicle.
• Promote efficient vehicle selection, maintenance, & use by fleet & individual drivers (P.L. 93-438)	Automobile driver training courses P2A/DOT Joint Voluntary Truck & Bus Program	.2 Initiate DECAT	.3 Distribute fuel economy film	.6 10 regional teaching	.9 Mock DECAT instructor trained Started DECAT for truckers	• 3% of fleet drivers 81 via DECAT in 1981 • 333 member organizations in Vol. Truck & Bus Program
• Prepare contingency plans and develop methodology for setting state consumption targets for gasoline use (P.L. 96-102)	None	0	0	.5 Developed target methodology Assisted many states	.3 Used and modified methodology. Reviewed 26 state plans	• Developed state gasoline targets • Satisfied the requirements of the Standby Federal Emergency Energy Conservation Plan required by ERCA 1979 (P.L. 96-102) • 26 State received assistance
ALTERNATIVE FUELS UTILIZATION						
Work with fuel suppliers & engine manufacturers to optimize fuel/engine interface (P.L. 93-238)		$2.4	$3.8	$3.3	$3.9	
• Conduct proof-of-concept testing of 3 engine/fuel combinations		Evaluated straight alcohol	Initial study of fuel/engine tradeoffs	Tested 3rd generation alcohol vehicle	Complete evaluation of liquid hydrogen in baseline vehicle	• Completion of evaluations slipped from 1981 to 1983 due to lack of funds
• Demonstrate feasibility of using unique fuels in appropriate engines			Worked to remove problems with ethanol use	Completed feasibility of modified SRC phenols in gasoline	Completed engine modification of Post Office Alcohol Vehicle	• Regular roundtable forums of involved persons
• Assess practicality of using methanol (P.L. 96-512)						• Technology base established
TRANSPORTATION PROGRAM TOTAL		$42.9	$46.0	$108.0	$103.9	

TABLE 2

CURRENT PROGRAM OBJECTIVES AND BUDGET

GOAL/OBJECTIVE	ALTERNATIVES	ANTICIPATED NEEDS	BUDGET JUSTIFICATION & SERVICES PROVIDED
VEHICLE PROPULSION TECHNOLOGY DEVELOPMENT			
To develop technology & components that are cost-effective & fuel efficient • Develop low thermo-conductivity ceramic materials • Develop ceramic rotor capable of 3500 hr. life at 2500°F and 180,000 RPM • Develop improved reciprocating seals • Improve heavy duty diesel engines by 30% through utilization of waste heat • Develop component technology (bearings, heads, pistons) for uncooled diesel engines	P.L. 93-238 (1974) requires R&D on advanced automobile propulsion systems	• DOE mandated by P.L. 93-238 to perform R&D on heat engines • The domestic vehicle manufacturers have neither the profits nor the time horizon to allow them to spend R&D funds on generic, long-run, risky research with potential high payoff. • Foreign governments are aiding their vehicle manufacturers to provide advanced propulsion vehicles.	FY 82 $11 M FY 83 $6.4 M Estimated outyear $30 M FY 84-FY 90 Ceramic parts will allow a wider spectrum of engines to run at higher temperatures and therefore at higher efficiency levels. Heat currently rejected by engines can be used to generate more power or reduce power of main engine thus increasing efficiency
ELECTRIC & HYBRID VEHICLE DRIVE			
Advance the development of EVs & HVs • Increase EV range to 100 miles • Increase battery life to 30,000 miles • Develop non-petroleum full performance hybrid vehicle	P.L. 94-413 (1976) requires R&D for electric and hybrid vehicles P.L. 95-238 alters the demo schedule and changes term P.L. 96-185 includes EVs in auto mpg standards	• Technological deficiencies in current EV batteries & components. • DOE mandated by P.L. 94-413 to perform R&D on EV & HV. • Only GM has developed plans for producing an EV, and the target date has slipped 2 years to 1987. • Federal funds are necessary to conduct risky research that no small manufacturers can afford and no big company will currently start. • Start market penetration in 1987 rather than in late 1990's without federal assistance. • Government program needed to keep momentum going on EV research.	FY 82 $19.4 M FY 83 $17.0 M Estimated outyear $140 M FY 84-FY 90 Increased range and battery lifetime at modest cost will make EV more competitive as second car in many households
TRANSPORTATION SYSTEMS UTILIZATION			
To make Gas Mileage Guide available to all new car dealers.	P.L. 94-163 (1975) requires publications and distribution of Guide	• DOE mandated by P.L. 94-163 to produce and distribute MPG Guide.	FY 82 $1 M FY 83 $1 M Estimated outyears $6 M FY 84-90

PROGRAM: MULTI-SECTOR CONSERVATION

ADMINISTRATOR: Assistant Sector for Conservation and Renewable Energy

The Multi-Sector Conservation Programs include the Energy Conversion and Utilization Technologies Program, the Energy Related Inventions Program, and the Appropriate Technology Small Grants Program.

ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES PROGRAM

PROGRAM OBJECTIVES: The Energy Conversion and Utilization Technologies (ECUT) Program supports long-term, high-risk applied research and exploratory development necessary to assure the availability of a future technology base that will enable a substantial increase in both the efficiency of energy conversion and utilization equipment and the increased use of non-critical fuels.

In its Statement of Policy (Section 3, PL 93-577, Federal Non-Nuclear Energy Research and Development Act of 1974), the Congress declares its purpose "to establish and vigorously conduct a comprehensive, national program of basic and applied research and development, including but not limited to demonstrations of practical applications of all potentially beneficial energy sources and utilization technologies within the Energy Research and Development Administration."

In President Reagan's Message to the Congress of the United States on February 18, 1981, entitled, "A Program for Economic Recovery," he recommended retention of "high potential projects that are unlikely to be supported by the private sector alone because they are high-risk and long-term, or apply to many industries."

Federal participation in the advanced energy technology areas is necessary because marketplace forces neither motivate nor reward the private sector sufficiently to induce it to perform all such required research unassisted. ECUT activity, properly focused, obviates loss of important research opportunities, losses occasioned by the long time lag and high-risk costs associated with development of innovative ideas. It will enhance the flow of improved energy systems to the private sector on a time scale consistent with the goals of an expanding economy.

The ECUT Program was established in FY 1981 as a technology base program, that is, a program consisting of research and exploratory development activities designed to produce improved generic technologies to support development of more efficient energy systems. The need for increased technology base activity was recognized by two DOE task forces - the Materials Working Group and the FY 1981 Technology Base Assessment - which reported to the Research and Development Coordination Council. Both task forces recommended that CE devote resources to meet this need and develop a comprehensive technology base program in support of all energy end-use sectors. In addition to its function of improving the technology base for energy conservation applications, the ECUT Program serves as an interface between the Energy Conservation Programs and the Basic Energy Science Program of the Office of Energy Research.

The overall goals of the ECUT Program are to:

- o Expand the technology base available to the private sector for development of improved energy systems and devices; and
- o Evaluate new or innovative concepts for improved efficiency or alternative fuel use in energy conversion systems or utilization devices.

The initial objectives of the ECUT Program, which are presented in Table 1a, are defined in terms of technological accomplishments to support private sector efforts to develop improved heat engines, combustion equipment, heat exchangers, and industrial process equipment.

In initiating ECUT activities in 1981, the Engine Combustion Technology, Closed Cycle Power Systems, and Physical Processes Projects were organized in part around existing activities transferred from other divisions in DOE. The balance of the projects, (Direct Heating and Conversion; Chemical Processes; and Materials) were funded at minimal levels to support research opportunities identification, selection, ranking and planning.

There have been some shifts in the program focus as a result of funding level changes. Activities in the Closed Cycle Power Systems Project will be redirected in FY 1983 and a realignment of the objectives with presently anticipated funding levels has been necessary. Details of the current objectives are given in Table 2a.

PROGRAM IMPACTS: Successful implementation of the ECUT program will create a technology base from which conversion and utilization devices/processes with energy efficiency and alternative fuel use capability improvements can be realized in the years 1990 and onward. Since ECUT undertakes long-term, high-risk R&D, the degree to which the original objectives of the program have been achieved can only be ascertained in the short-term by the timely accomplishment of intermediate milestones. Details of the program status and the degree of achievement towards the program objectives are shown in Table 1a.

A large segment of the energy consumers will benefit from ECUT sponsored research. Expansion of the technology base presently available to the various energy end-use sectors will allow for opportunities in increasing energy use efficiency to be identified. In addition, an increase in alternative fuel use capability will enable displacement of fuels from critical sources. Benefits to be derived are not limited to energy savings. Economic stability is increased by investing the money saved from oil imports in more productive ventures. This combination results in an increase of both capital and energy productivity which has historically lagged behind labor productivity. Other benefits to be derived once the technology base is in place and available to the various sectors will be creation of new employment opportunities as a result of increased capital formation and reduction of the costs of U.S. goods due to reduced energy cost components.

There are no specific National Environmental Policy Act requirements that need to be addresed at present due to the fact that ECUT is primarily in the early development stages in most of its projects. As project plans are developed, special care will be taken to identify actions that might require environmental impact statements. In addition, attendant environmental and safety problems

that will need resolution will be addressed together with the technical and economic constraints. It is anticipated that as conversion efficiency improves, the decrease in fuel requirements will lead to subsequent improvement of the environment.

PROJECTED PROGRAM REQUIREMENTS: The ECUT budget request for FY 1982 is $12M. However, the anticipated funding level for FY 1983 is only $6.5M. This level of support will not allow continuation of current R&D activities or timely accomplishment of the objectives detailed in Table 1a.

DISCONTINUATION REQUIREMENTS: Phase-out of the ECUT program would require approximately $4.0 million in contract closeout costs and result in the loss of over 30 scientists and engineers in government funded laboratories. Within CE, ECUT was established as the only program dedicated to long-term applied research and exploratory development of advanced/innovative concepts in energy conversion and utilization. Should funding of ECUT be disrupted, there are no current DOE organizations that could immediately absorb the program responsibilities. Other government agencies such as NSF, Commerce/NBS, or Interior could possibly continue ECUT efforts but these groups would require a minimum of two years to reach a comparative level of effectiveness. In addition, these non-DOE organizations would not share the appropriate energy perspective offered by conducting this program within DOE. Private industry, historically, has not been motivated to conduct long-term, high-risk research activities to improve energy conversion and utilization efficiency. Therefore,this research would probably not be pursued by the private sector unless taxincentives or regulations were enacted to provide the incentive. Foreigngovernments actively pursue energy research with their respective industrialpartners which offers U.S. industry the option of relying on the purchase offoreign technology for future energy efficient equipment.

In addition, phase-out of the ECUT Program would impact U.S. participation in international cooperation in energy-related research. The ECUT Program provides resources and management for two projects under the International Energy Agency. U.S. participation in the IEA projects on Combustion Research and Heat Transfer and Heat Exchanger Research began in 1976, and significant benefits have accrued to U.S. industries from this cooperative activity. Funding and management resources will have to be derived from other programs to continue U.S. participation in these projects.

The truly significant impacts resulting from phase-out would not appear in the near term because ECUT is a long-term research program. The far-term effects, however, could seriously jeopardize the nation's goal of utilizing energy efficiently aand economically. Research cannot be simply turned on and off as the occasion demands. There is a considerable time lag associated with the development of worthwhile innovative ideas from conception through feasibility to commercialization. Tomorrow's technological demands must be addressed at the present.

Energy-Related Inventions Programs

PROGRAM OBJECTIVES: The Energy-Related Inventions Program was established by Section 14 of P.L. 93-577, the "Federal Nonnuclear Energy Research and Development Act of 1974." The program objective from Section 14 of the Act is to "...(evaluate) all promising energy-related inventions---for the purpose of obtaining direct grants from the (ERDA) Administrator," now DOE. The need which the program specifically addresses, and an implied limitation, is to give attention "particularly (to) those (inventions) submitted by individual inventors and small companies." The program also has a basic DOE mission role as defined by Congress in their "Conference" report, page 30, regarding Section 14 which says: "The conference committee directs the National Bureau of Standards (NBS) to keep ERDA currently advised of promising inventions which should be considered for inclusion in the energy research, development, and demonstration programs." Per PPA request the program has requested a funding of $4.962 million in FY-83, for activities essentially as in FY-82. A 10% plus funding would be assigned for additional grants. A 10% less funding would need to be applied to reduce the level of the NBS activities. The program as defined by the Act and as it has developed, is a type of Small Business Innovation Research (SBIR) program. There are initial phases of technical screening and in-depth analysis and invention selection at the NBS, followed by various kinds of grant support and technical assistance in the DOE portion of the Inventions Program. The Inventions Program is the only Federal program, providing support to individuals and small businesses, specifically in the field of energy-related inventions.

The objectives (Table 1 and 2) of the program, therefore, are to: 1) evaluate the technical merits of all submitted energy-related inventions, 2) provide assistance for the RD&D of energy-related inventions by individuals and small businesses, 3) to encourage invention and innovation by individuals and small businesses through information dissemination, in view of a program finding of their need for such information and 4) conduct a cost effective system of technical and progress monitoring of funded inventions.

PROGRAM IMPACTS: Since 1975, the first year of the program, 16,780 requests for evaluation of energy-saving inventions have been received and processed by NBS. Of these, to date, NBS has recommended 175 inventions to DOE for support. The "expected yield" at NBS is 1.3 percent, a figure that is in line with yields that have been experienced in other similar programs such as those in Great Britain and Denmark. Ninety-five of these have been awarded grants totaling $7 million.

There are specific indications, as follows, of program success, though it is too early to assess fully the impact of the program on the national energy scene. Also, the same information indicates who are the principal program beneficiaries, and the degree to which Congressional intent has been met: 1) A large percentage of the inventions with industrial applications have the potential for increasing productivity in key industrial processes such as aluminum, steel, oil-well drilling, and coal mining. Two such specific inventions which also have environmental benefits represent instances illustrating cost effectivness where one grant and the credibility received from the program has effectively put the entrepreneur in a marketing position to impact an entire industry. 2) A number of inventors supported by the program, such as the two referred to above, say that without the credibility and the grant support they received from the program, they would not have been able to reach the marketplace by themselves. 3) Returns to the Federal Government will be

PROGRAM: STATE AND LOCAL ASSISTANCE PROGRAMS

ADMINISTRATOR: ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

PROGRAM OBJECTIVES:

In accordance with Federal mandates, the Office of State and Local Assistance Programs (SLAP) is responsible for administering grants, providing technical assistance, and offering guidance to state energy offices, local governments, small businesses, organizations, and individuals on energy conservation, energy outreach, energy efficiency, energy technologies, and alternative energy programs. The four SLAP programs are: (1) Energy Extension Service (EES); (2) State Energy Conservation Programs (SECP); (3) Weatherization Assistance Program (WAP); and (4) Schools and Hospitals-Local Government and Public Care Grant Programs.

By passing the four major pieces of legislation that established these programs, Congress recognized the importance of state and local governments in encouraging energy conservation. SECP plans were first described in the Energy Policy and Conservation Act of 1975 (EPCA, P.L. 94-163), and SECP supplemental plans were first described in the Energy Conservation and Production Act of 1976 (ECPA, P.L. 94-385). ECPA also established the low-income weatherization program. Formation of an Energy Extension Service in 1977 was the intent of the National Energy Extension Service Act of 1978 (NEESA, P.L. 95-39, Title V). The National Energy Conservation Policy Act of 1978 (NECPA, P.L. 95-619) contained authorizations for state utility plans, additional weatherization programs, grants for schools and hospitals, and local government and public care grants program.

Energy Extension Service (EES). The goal of EES was to establish energy outreach programs in the states directed toward public institutions, small businesses, and individual energy consumers. In turn, the purpose of the state programs was to provide personalized assistance to these energy users on energy-efficient technologies and other opportunities to reduce energy consumption and shift to renewable energy resources. Provisions were included in NEESA for program evaluation and technical assistance by DOE to states in support of their EES efforts, as well as for financial assistance to the states through Federal grants.

State Energy Conservation Program (SECP). Under SECP, states were to develop and implement plans designed to reduce projected 1980 energy consumption by 5 percent or more. Each state plan was required to include eight measures: lighting efficiency standards; ridesharing programs; energy-efficient procurement practices; building thermal efficiency standards; right-turn-on-red; public energy education; intergovernmental coordination; and, energy audits for buildings and industrial plants. In addition, state plans have included other measures to help achieve energy conservation goals--e.g., beverage container regulations, energy management training, car care projects, and woodburning stove programs. A related goal of SECP was to develop state capability to manage energy conservation activities, primarily through the establishment of state energy offices. In

addition to financial assistance through grants, SECP has supported state efforts by providing technical assistance, training workshops, and information-sharing activities that enabled states to exchange program results.

Weatherization Assistance Program. The goal of the Weatherization Assistance Program is to make the modifications necessary to provide for energy efficiency in dwellings owned or occupied by low-income persons. Weatherization of such dwellings will lower utility expenses for low-income owners or occupants, as well as conserve needed energy. The conservation efforts undertaken by this program would not have been done in the absence of this program. The primary clients, the elderly, poor, and handicapped, could not have undertaken these conservation efforts on their own. There are approximately 13.1 million households eligible for this program.

One historical objective of the Weatherization Assistance Program was to award annual grants to 50 states, the District of Columbia, and 25 Native American tribal organizations to weatherize approximately 775,000 homes by the end of fiscal year 1981. In addition, the Community Services Administration* weatherized approximately 400,000 homes, for a total of 1.175 million homes weatherized under the two programs. Another objective was to effect an energy savings of 4,700,000 barrels of oil equivalent (BOE) per year (including the CSA homes).

During the program's first 3 years, operational problems slowed anticipated production rates. However, progress has been made in addressing the needs attendant to the program by effecting significant legislative, regulatory, and administrative changes. These changes resulted in greater flexibility in grant funding, hiring of labor, installation of interim weatherization measures, and provision for multi-family rental units. The program's enabling legislation has been amended twice, by NECPA (P.L. 95-619) in 1978 and by the Energy Security Act (ESA) (P.L. 96-294) in 1980. The regulations were amended, where necessary, to comply with these legislated changes (see the final rules published in the Federal Register on May 31, 1979, and August 29, 1979, for the NECPA changes, and the amendment to the interim rule published on June 1, 1981, for ESA changes addressed to date). The administrative changes provided for greater program visibility and needed support from the top level of DOE and for the initiation of a comprehensive monthly reporting system.

From the beginning of the program until January 31, 1981, the program assisted a total of 946,124 low-income persons, including 349,312 elderly and 86,618 handicapped persons. From fiscal year 1978 through June 30, 1981, the program weatherized 699,891 homes at a cost of $442,735,960, which saved a total of 2,799,564 barrels of oil equivalent.

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*From 1975 to 1978, the Community Services Administration (CSA) ran a similar program whose results have traditionally been included with DOE's because of the close relationship between the two programs.

Schools and Hospitals-Local Government and Public Care Grant Programs. Congress established these grant programs (also known as the Institutional Conservation Programs) with the goal of providing financial assistance needed to overcome barriers to energy conservation. Institutions and municipalities are in unique fiscal situations which prevent free-market forces from being effective in reducing energy use in that sector. Schools and local governments operate on budgets that are fixed, at best, and often declining. Rising energy costs (school energy costs have tripled in the past 4 years) cannot be passed through; they must be absorbed at the cost of basic education programs and community services.

Health care institutions, on the other hand, operate under a cost-based reimbursement system that does not necessarily reward the efficient use of energy. There is little incentive for a hospital to increase its energy conservation activities, and, in fact, hospitals can be penalized when they cut operating costs beyond a certain point.

The grant programs have two phases. The first phase provides grants to the states to enable them to:

- o Conduct preliminary energy audits (PEA's) of school and hospital buildings and buildings owned by units of local government and public care institutions to assess the number, types, and energy use characteristics of the buildings in the sector for the purpose of developing state plans; and

- o Provide energy audits (EA's) to all interested schools, hospitals, and local governments and public care institutions in the state to assist them in identifying and implementing energy conservation operating procedures.

The second phase provides grants to enable:

- o States, schools, hospitals, and local government and public care institutions to undertake technical assistance (TA) projects (engineering studies of energy conservation potential) in school and hospital facilities; and

- o Schools and hospitals to acquire and install energy conservation measures (ECM) in their facilities.

Program accomplishments for the various SLAP programs are outlined in Table 1.

PROGRAM IMPACTS:

Energy Extension Service (EES). Based on the favorable results of the 2-year, 10-state pilot program, EES was expanded nationwide during fiscal year 1980. Fifty-seven states and territories have offered personalized assistance to energy users on practical, energy-saving opportunities. Services such as energy audits and self-help workshops are tailored by the

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states to the needs of homeowners, small businesses, local governments, and other public institutions. States are given broad flexibility in designing services so that particular local needs can be met through the program and so that EES activities can be used to supplement or complement other conservation and renewable resource programs.

Evaluation of the EES pilot program* indicated that 90 percent of the clients found the service provided useful; 51 percent found the EES service more useful than that from any other source. Sample EES clients in the 10 pilot states saved the equivalent of 6,400 barrels of oil per day beyond what would have been saved without the program. The cost of achieving these additional energy savings averaged $8.50 per barrel of oil equivalent. Compared to the cost of buying a barrel of imported oil ($30-35), EES has been cost effective.

Sample EES clients invested $59.9 million more in energy conservation measures than did comparable nonclients. Since the EES program cost was $2.5 million for the 10 pilot programs, EES expenditures leveraged $24 of private investment in conservation for every EES dollar expended.

In addition, the program had a multiplier effect in stimulating self-sustaining action by others. For example, a San Diego, California, program in which senior citizens provide technical assistance to other senior citizens has been picked up on its own by communities throughout the state.

EES has spearheaded a technical assistance concept and operation that pulls together existing resources, makes them easily accessible to states, and encourages the building of independent state capability for handling repetitive needs.

State Energy Conservation Program (SECP). The state-reported 1980 SECP energy savings were 3.1 quads, a 4-percent reduction in estimated 1980 energy consumption. A more conservative analysis by DOE estimates that 33 million barrels of oil equivalent were saved by selected SECP program measures in 1980. The lifetime value of these savings is estimated at $13 billion. Using a total Federal cost of SECP of $217 million for fiscal year 1976 through fiscal year 1980, this yields a benefit-to-Federal-cost ratio of 60.

Most states did not have state energy offices prior to implementation of SECP. Under the program all states have established or expanded their capability to plan, design, and implement a wide variety of energy conservation measures. Most of the eight required program measures are

*U.S., Department of Energy, Conservation and Renewable Energy, Energy Extension Service Pilot Program Evaluation Report for Two Years, 1980. (DOE-CS 2671)

being implemented on a continuing basis nationwide, as well as additional innovative measures developed by the states to assist in meeting their energy conservation goals.

Sixty percent of the states' reported energy savings have been achieved by the voluntary state activities. Some examples of innovative programs the states have developed under SECP to meet their needs are:

- State tax incentives to manufacturers and purchasers of solar equipment (Puerto Rico);
- Energy audits, improved energy management, conservation retrofits, and computerized monitoring of energy consumption in state buildings (Montana);
- Industrial consortia for exchange of information on fuel conversions, cogeneration, and other aspects of energy conservation (Missouri);
- Energy resources groups to implement procedures for energy-efficient procurement (Illinois); and
- Recycled paper purchases (Maryland).

Weatherization Assistance Program. The Weatherization Assistance Program has no truly measurable impact of significance on the Nation's health and safety. However, with more weatherproofed homes, low-income persons, particularly the elderly and handicapped, are more comfortable and less susceptible to illnesses caused by excessive heat or cold, and with reduced energy costs, they are financially better able to meet their medical and nutritional needs.

Schools and Hospitals-Local Government and Public Care Grant Programs. Early indications are that the goal and objectives set by Congress are being met. Specific program accomplishments are shown in Table 1. Every state is participating in the grant programs. Preliminary energy audits have been conducted in total or on a sampling basis for each state. The states estimate that energy audit grants awarded will result in energy savings of 10 percent to 15 percent in participating institutions.

The greatest economic impact of these programs is, of course, the reduced operating costs in participating institutions. The energy conservation projects funded have created design and construction jobs. The $225 million Federal grants obligated in these programs have resulted in a total investment of $450 million, which is more than 30 percent of the total value of all construction put in place for schools and hospitals in 1978.

The State of Illinois conducted an evaluation of the energy audits done in their schools and found that each dollar invested in the program was paid back four times over in energy savings in the first year. Over the next 5

years, Illinois projects that their costs will be $2.6 million and energy savings of $47 million, a ratio of $18 in energy savings for every dollar of costs.

Also, an engineering study was made of Institutional Conservation Programs grants in Wisconsin. The survey found an average energy savings of 15 percent in school buildings where operation and maintenance measures were incorporated, and an average cost savings of $11,543 per building (contrasted with a Federal investment of $300 to $400).

State offices also indicate that the grants awarded for technical assistance projects have been valuable to institutions in enabling them to plan for capital investments in energy conservation. Technical assistance grants generally also have identified additional low-cost operations and maintenance measures that enable institutions to realize immediate energy savings.

It is too soon for records of actual energy savings to be available, but engineering estimates of savings indicate that the program has funded extremely cost-effective energy conservation measures. Data from the Chicago Operations Office indicates that the costs of EDM grants awarded from that office will be recovered from energy savings in 2 to 5 years.

Calculations based on statistics from the EDM grantees in Wisconsin indicate that EDM grants have saved 1,469,276 BOE in hospitals across the country, with an average cost per BOE of $4.31 (Federal share), assuming a conservative 10 years useful life for EDM. On the basis of the same calculations, EDM grants have saved 1,040,379 BOE in schools, at a cost of $11.30 per BOE. In terms of cost savings, the statistics indicate that the Federal investment in school EDM's will be paid back in 2.28 years, and 0.87 years in hospital EDM's.

Medicare/Medicaid reimbursements of hospital expenses, including energy costs, is about 45 percent of the total. Using current projects and an estimated useful life of 10 years, it is estimated the program results in a $1.38 savings to the Federal Government for every dollar invested.

DOE is designing a detailed survey of eligible institutions and local governments to determine what measures have been most effective in reducing institutions' energy use and what types of actions have been taken by grantees and to quantify the other impacts of the program.

PROJECTED PROGRAM REQUIREMENTS:

Of the SLAP programs, only the Schools and Hospitals-Local Government and Public Care Grant Programs will be continued in fiscal year 1982. The fiscal year 1982 budget requests $100 million, which will provide for approximately 1,200 technical assistance grants and 1,350 energy conservation measure grants. A budget increase of 10 percent would allow an additional 120 TA grants and 135 EDM grants. A budget reduction of 10 percent would mean only 1,080 TA grants and 1,215 EDM grants would be aprogram. Table 2 summarizes current program objectives and budget.

DISCONTINUATION REQUIREMENTS:

SLAP has approximately 15,000 grants active in the field at present. Most of these will be completed within the next year. All that would be required to discontinue the program would be $2.5 million for an orderly closeout of these projects as they are completed.

Part I

STATE AND LOCAL ASSISTANCE PROGRAMS
PROGRAM ACCOMPLISHMENTS

BUDGET DATA ($ Millions) STATUS

Goals/Objectives	Other Programs (Duplicative)	FY 78	FY 79	FY 80	FY 81	DEGREE ORIGINAL OBJECTIVE MET
STATE ENERGY CONSERVATION PROGRAM		$71.5	$57.8	$47.8	$40.4	(OBLIGATIONS)
To reduce energy consumption in states by at least 5% of projected 1980 levels	o A number of Federal agencies provide complementary but not duplicative programs	o SECP plans implemented by 50 states and 5 territories	o Energy savings: 108 quads	o Energy savings: 197 quads	o Energy savings: not yet available	o Energy consumption reduced 4%
Implement mandatory energy conservation measures in states		o States develop legislation	o Most states have adopted most mandatory measures	o Most states are implementing most mandatory measures	o Most states are implementing most mandatory measures	o Most states are implementing most mandatory measures
Assist state energy offices in facilitating development of state energy conservation capabilities		o Provided states with onsite technical assistance, program workbooks, and program workshops	o Provided states with case studies of best practices, held program workshops and several national conferences on individual measures	o Provided evaluation technical assistance	o Developed simplified evaluation system	o Energy conservation capability established in 57 states and territories
ENERGY EXTENSION SERVICE		$5.2	$6.1	$29.6	$20	(OBLIGATIONS)
To develop a pilot EES program to be expanded nationwide		o Grants awarded to 10 pilot state programs	o Grants continued to pilot states	o EES national program awarded to 50 states; 7 territories approved	o Nationwide program being implemented	o Nationwide program being implemented
To provide assistance to small businesses and individual consumers to reduce energy consumption		o Impacts for 1978 and 1979 are shown in 1979	o Energy savings: sample clients saved 6,400 barrels of oil equivalent per day (BOE) they would not have otherwise saved. The total Federal and private cost was $8.50 per BOE o Satisfaction: 90% of clients found the services useful; >1% found them more useful than those from other sources	o Energy savings: not yet available	o Energy savings not yet available	o Cost-effective energy savings achieved with a high degree of client satisfaction in the pilot program

TABLE 1
(Continued)

Goals/Objectives	Other Programs (Duplicative)	FY 78	FY 79	FY 80	FY 81	DEGREE ORIGINAL OBJECTIVE MET
WEATHERIZATION		$65	$198.95	$198.95	$181.976	
Award annual grants to 50 states, the District of Columbia, and 25 Native American tribal organizations to weatherize approximately 1.1 million homes by the end of FY 81	o More targeted specifically for low-income households	o 77,500 homes weatherized o 310,000 BOE saved o 49 state grants awarded annually and 25 Native American grants awarded annually	o 123,000 homes weatherized o 492,000 BOE saved	o 265,000 homes weatherized o 1,060,000 BOE saved o Established special projects office to provide visibility and support to DOE	o 217,897 homes weatherized as of 6/31/81 o 861,588 BOE saved	o 1,175,000 homes weatherized o 4,700,000 BOE saved o Hawaii entered program beginning in FY 81
SCHOOLS AND HOSPITALS/ LOCAL GOVERNMENT AND PUBLIC CARE BUILDINGS		$27.5	$125.6	$143.75	$150	
To enable states to conduct preliminary energy audits to assess numbers, types, and energy use characteristics of eligible buildings To enable states to provide energy audits assisting eligible institutions To enable states, schools, and hospitals to undertake technical assistance projects (i.e., engineering studies of conservation potential) To enable schools, hospitals, and public use buildings to acquire and install energy conservation measures	o SECP and EES provide funds for energy audits	o Authorizing legislation enacted 54 grants to states to conduct PEA's/EA's in schools, hospitals, local government and public care buildings		o EA's conducted in 71,000 buildings o 7,423 grants for TA's/ECM's in 20,174 buildings o Estimated energy savings: 9.7 million BOE	o Estimated 7,000 grants for TA's/ECM's in 15,000 buildings o Estimated energy savings: 2.2 million BOE	o Estimated energy savings: 11.9 million BOE

TABLE 2

STATE AND LOCAL ASSISTANCE PROGRAMS
CURRENT PROGRAM OBJECTIVES AND BUDGET

($ Millions)

BUDGET FY 81: $100
Estimated: $ 4.894
Outyear costs

Goals/Objectives	Alternative Methods	Anticipated Needs	Budget Justification and Services Provided
SCHOOLS AND HOSPITALS			
o Provide cost-sharing grants to institutions for: - technical assistance analyses (i.e., engineering studies of energy conservation potential) - acquisition and installation of energy conservation capital investment measures	o Rely on private companies such as Trane and Honeywell o Rely on state governments to provide financial assistance o Use alternative Federal assistance, such as revolving loan fund, loan guarantees, or block grants	o Allow public institutions to take advantage of energy conservation potential where an incentive presently exists o Allow public institutions to take advantage of services offered by private sector	o Provide technical assistance analyses and energy conservation measures for 8,400 buildings with an energy savings potential of 4.1 million BOE
LOCAL GOVERNMENT AND PUBLIC CARE			
o Provide cost-sharing grants to institutions for technical assistance analyses (i.e., engineering studies of energy conservation potential)			

OCT 13 1981

PROGRAM: POWER MARKETING

ADMINISTRATOR: Assistant Secretary for Conservation and Renewable Energy
Administrator, Alaska Power Administration
Administrator, Bonneville Power Administration
Administrator, Southeastern Power Administration
Administrator, Southwestern Power Administration
Administrator, Western Area Power Administration

PROGRAM OBJECTIVES

Beginning in the early 1900's, the Federal Government undertook to conserve, develop, and manage the water resources of the United States comprehensively on a river basin basis. This policy was implemented initially through the Corps of Engineers (Corps) in the Department of the Army and the Bureau of Reclamation (Reclamation) in the Department of the Interior. Those agencies were authorized to construct and operate multiple-purpose water projects in the various river basins of the Nation to provide domestic and industrial water supplies, irrigation water for agriculture, navigation, flood control, recreation, fish and wildlife habitat, pollution and salinity control, and hydroelectric power. The Corps emphasized navigation and flood control; Reclamation, irrigation. Comprehensive river basin plans were developed and individual project studies determined which features should be incorporated in each facility.

In 1906, the Secretary of the Interior was authorized to market hydroelectric power from Federal reclamation projects. In the 1930's the Secretary was further authorized to construct and operate transmission lines to market power and in the Flood Control Act of 1944 was also authorized to market all power produced at Corps projects. Beginning in 1937, with the establishment of the Bonneville Power Administration (Bonneville) power marketing was assigned to separate regional power administrations. In 1977, in the Department of Energy Organization Act, Congress transferred to the Department of Energy the then existing four power marketing administrations and also the power marketing functions of Reclamation, which were then organized into a fifth regional power marketing administration.

Although more than 100 statutes now govern the power marketing program, three of these lay the foundation for the present activities of the five power administrations: the Bonneville Project Act of 1937, 50 Stat. 731; the Reclamation Project Act of 1939, Section 9, 53 Stat. 1194; and the Flood Control Act of 1944, Section 5, 58 Stat. 890. Additional legislation within the last decade has especially expanded the role of Bonneville. The Federal Columbia River Transmission System Act of 1974, 88 Stat. 1376, P.L. 93-454 authorized Bonneville to integrate generation from all sources within the region and to place its revenues in a revolving fund and expend them for purposes necessary in the performance of its duties. The Act also authorized BPA to borrow up to $1.25 billion through the issuance of revenue bonds. The Pacific Northwest Electric Power Planning and Conservation Act of 1980, 94 Stat. 2697, P.L. 96-501, authorized Bonneville to acquire power from non-Federal sources to meet the requirements of its customers which exceed their capability to meet their own needs prior to enactment of the Act. Priority must be given in such acquisition to cost-effective conservation measures and renewable energy resources. The Act also obliges Bonneville to protect, mitigate, and enhance the fish and wildlife resources of the Columbia River and its tributaries.

Five Federal power administrations have been created over the years to carry out the program requirements. They are: Alaska Power Administration (Alaska), established in 1967; Bonneville established in 1937; Southeastern Power Administration (Southeastern), established in 1950; Southwestern Power Administration (Southwestern), established in 1943; and Western Area Power Administration (Western), established in 1977 from functions previously performed by the Bureau of Reclamation. The power marketing administrations (PMA's) are responsible for marketing the power produced at all Federal multiple-purpose water projects, except those in the Tennessee Valley.

Federal hydroelectric power is priced to recover all costs of producing and marketing the power, including recovering the capital invested, with interest, over a reasonable period of years, not to exceed 50 years. Interest is usually determined at the start of construction and is based on the average yield on long-term Treasury bonds. Revenues annually recover the operation and maintenance costs of the Corps and Reclamation as well as each power administration, the costs of any power purchased to make the available hydropower marketable, the costs of wheeling services provided by other utilities, interest on the unamortized capital debt, and a portion of the capital invested in power and in irrigation features beyond the ability of the water users to repay. Bonneville, being self-financed, uses its revenues directly to pay annual costs and to return capital to the Treasury. The other power administrations deposit their revenues in the Treasury and obtain appropriations from the Congress to operate and maintain their systems, purchase power and wheeling, and undertake needed capital investments for transmission construction and rehabilitation.

To carry out their functions, the power marketing administrations have the following primary goals: 1. Market all hydropower available from Federal dams. 2. Market all power at the lowest possible rates to consumers consistent with sound business principles to recover the costs of operation and capital invested with interest. 3. Repay capital invested within a reasonable period of years, usually 50. 4. Give preference in the sale of power to public bodies and cooperatives. 5. Construct and operate transmission lines with a high degree of system reliability. Develop technology in high voltage transmission (BPA). 6. Market power at uniform rates to encourage the most widespread use of electricity. Some goals apply to only one power administration: 7. Alaska: Operate and maintain the Eklutna and Snettisham generating stations. 8. Alaska: Conduct general investigations of potential renewable electric power resources in Alaska. 9. Bonneville: Acquire resources, through conservation and other acquisitions, sufficient to meet the Administrator's net obligations. 10. Bonneville: Protect, enhance, and mitigate fish and wildlife resources of the Columbia River and its tributaries.

The Federal power marketing functions are not duplicated by any other Federal program. Alternatives to the present system are limited by the complex relationships of the power marketing program to the diverse objectives of the Federal water resources management programs in the various river basins. Power will continue to be generated and transmitted from Federal dams largely in response to other multiple-purpose water project objectives. The question is what alternatives are reasonable to market the power in a responsible and orderly manner which will ensure recovery of the Government's investment and costs of delivery.

Among these alternatives are:

1. Create regional entities, either public or quasi-public, composed of both consumer and investor-owned utilities, to market the power and repay the Federal investment. This alternative might require a large capital investment to buy out the Federal interest. This would require a major legislative change.

2. Create a government corporation to administer the power marketing program. It could have a Board of Directors drawn from the regions served by the power marketing administrations and could be self-financed from the revenues generated by rates charged to customers. This would require a major legislative change. This might or might not require a large capital investment depending on legislative action.

3. Retain the existing Federal power marketing administrations. This would preserve the long-established principles of the power marketing program, but would leave several organizational options:

a. Continue the power marketing program in the Department of Energy. The five power administrations now report directly to the Assistant Secretary for Conservation and Renewable Energy. Their work is coordinated by the Office of Power Marketing Coordination which also serves as a central staff to the Assistant Secretary and as the Washington liaison office of the Alaska, Southeastern, and Southwestern Power Administrations. The Assistant Secretary provides overall policy guidance and supervision to the five administrations and the Office of Power Marketing Coordination. Except for Bonneville, he also establishes rates on an interim basis and refers them to the Federal Energy Regulatory Commission for confirmation and approval on a final basis. He holds each administrator responsible for the day-to-day management of his administration.

b. Transfer the power marketing program to the Department of the Interior. The power marketing program was originally located in the Department of the Interior and was transferred to the Department of Energy in 1977.

c. Establish a separate Federal agency to administer the power marketing program. The five power administrations and the central staff with its legal support could be transferred intact to such an agency and operate immediately. Because the power marketing program recovers in rates all of its costs of operation, such a change could also be associated with placing the entire program on a self-financed basis.

PROGRAM IMPACTS

The goals of the power administrations are accomplished continuously. All objectives, except the new ones assigned to Bonneville by P.L. 96-501, which are now being implemented are regularly met. The power administrations are operating utilities. The marketing of power from 122 Federal water projects is a continuing process. All of the hydropower available has been sold, most of it under long-term contracts which expire at various dates between now and the year 2004. As additional capacity and energy are made available from new projects or from additions at existing ones, it is promptly allocated and sold. The demand for Federal hydropower far exceeds the supply.

In Fiscal 1980, the power administrations sold 123.3 billion kilowatt hours, about 45 percent of the Nation's hydropower production. They operate and maintain over 30,000 miles of transmission lines and related facilities such as switchyards, substations and power dispatch centers.

The five power administrations serve a total of 886 wholesale customers, of which 365 are municipal electric utilities; 209 rural electric cooperatives; 203 are other Federal, State, and county agencies, including public utility districts; 65 are irrigation districts, industries and other users; and 44 are investor-owned utilities.

In the Pacific Northwest, where hydro provides 80 percent of the electricity, the Federal hydro system provides half of the region's needs and the total energy requirements of many preference customers. Bonneville also provides 80 percent of the region's high voltage transmission. The Alaska Power Administration is the principal power supplier to Juneau and a major supplier to Anchorage and adjoining communities. Throughout the other Western states, the Western Area Power Administration provides the majority of its preference customers with firm power at a relatively high load factor. Southeastern and Southwestern sell most of their power for peaking purposes and supply only about 10 percent of the needs of their customers. Wherever it is sold, however, Federal hydropower provides a very valuable renewable energy resource which is especially useful for peaking purposes and which permits the conservation of oil, gas, and other non-renewable fuels used in the production of electricity.

The Federal power program has had a major impact upon the economy of the regions which it serves. The Pacific Northwest, which had been limited primarily to an extractive economy based upon lumbering, mining, and farming prior to the 1930's, has developed a balanced industrial base, including an aluminum industry which produces one-third of the Nation's aluminum supply and a major aircraft production industry. Low-cost hydropower has encouraged the development of many other related industries there. In the Missouri and Colorado basins, in California, and in the Pacific Northwest, Federal water development and low-cost Federal power have assisted the development of irrigated agriculture and of economic growth.

Hydropower is inherently anti-inflationary. Once the capital investment is made, there is no escalation of fuel costs and only minimal increases in costs of operation and maintenance.

An evaluation of the program's success shows that over the years the Federal power marketing administrations have maintained high operating efficiency and system reliability. All of the administrations have an excellent safety record, have kept outages to a minimum, and when outages have occurred, have restored service promptly and efficiently. In cooperation with the Office of Electric Energy Systems of DOE, they have developed extra high voltage transmission technology and in the Pacific Northwest have demonstrated the benefits of a highly efficient integrated regional transmission grid.

Another measure of operating program success concerns the allocation and marketing of power. All allocations, and all rate adjustments have been based upon substantial public involvement and participation. All five power administrations have maintained close contact with their customers and with organizations of customers both on a regional and on a national basis.

One assessment of the program is the adequacy of the revenues to recover the costs of operation and repay the capital invested with interest. Since the program began, Congress has invested a total of $10.6 billion in the power features of water resources projects and an additional $1.4 billion in the irrigation features which power users are expected to repay. Of this amount, $3.3 billion have been invested since 1975. Through FY 1980, the five power administrations had collected $10 billion in revenues. Those funds had been used to repay $3.3 billion in operating expenses by the generating agencies and the power administrations; $1.5 billion for the purchase of power and the wheeling of electricity; and $3.2 billion had been returned to the Treasury for interest on the unamortized balance of the debt. The remainder, $2 billion, had been applied to repay the capital investment, leaving $10 billion remaining to be repaid.

A second assessment of program adequacy is the number and size of rate adjustment actions taken to ensure repayment. Prior to 1978, rate adjustments had been relatively rare and relatively small for all of the power administrations. However, the inflation of the mid to late 1970's rapidly escalated purchased power costs. New facilities and replacements were much more expensive and carried a much higher rate of interest. Bonneville, being self-financed, faced interest rates comparable to those for investor-owned utilities. As a result, repayment studies conducted in 1977, 1978, and 1979 revealed the need for upward adjustment in many of the 22 rate systems. Between March 1, 1979 and June 15, 1981, 35 rate actions were approved. Of those actions, 17 involved rate adjustments that were sent to the Federal Energy Regulatory Commission for approval on a final basis. As a result of these rate actions, the largest number in the history of the power marketing program, the power administrations have assured timely repayment of Federal costs. The impact of these rate actions has been to increase power revenues from $701.8 million in Fiscal 1978 to $1,211.1 million in Fiscal 1981. Revenues are expected to reach $1,583.5 million in Fiscal 1982. Power purchase and resale provisions of the new Northwest Energy Act may increase Bonneville revenues and expenses an additional $500 million in Fiscal 1982. Repayment studies supporting these rate actions indicate that the new rates will recover costs at the lowest possible rate.

PROJECTED PROGRAM REQUIREMENTS

Alaska Power Administration: In Fiscal 1983, Alaska proposes to operate and maintain the Eklutna and Snettisham power projects and attendant transmission systems and to expand the market for Snettisham power. The cost will be $2,100,000. A 10 percent increase in the budget would permit Alaska to advance by about eight months completion of studies of the Snettisham underwater cable to serve outlying cities. If the budget is cut by 10 percent, it will be unable to replace an overaged bulldozer.

Alaska will also conduct general investigations of potential hydroelectric development, wind resources, and other domestic sources of energy, provide evaluation and studies of conservation measures, make transmission and power marketing analyses of hydroelectric projects under study by the Corps, and facilitate conversion of the State's major electric power systems to hydroelectric and other renewable resources. The cost will be $900,000. An increase in that amount will accelerate the Snettisham/Ketchikan tie studies, and continue the heat pump program with Juneau utilities. A cut will reduce transmission and wind resource studies.

Alaska expects power sales of 385 million kilowatt hours and revenues of $4.5 million in 1983.

Bonneville Power Administration: In Fiscal 1983 Bonneville will operate and maintain the Federal Columbia River Power System in accordance with prudent utility practice. It will purchase power resources to meet contractual obligations pursuant to Public Law 96-501. It will work with customer utilities to expand energy-conservation efforts in order to minimize the need for new generating resources, and will seek cost-effective renewable energy resources. It will undertake measures to protect, enhance, and mitigate problems affecting fish and wildlife resources of the Columbia River and its tributaries.

It will design and construct additions to the transmission system to meet customer needs, to improve system reliability, and to interconnect with other regions to exchange power and take advantage of load diversity. It will cooperate with regional utilities in Pacific Northwest power system operations and power planning. Pursuant to P.L. 96-501, Bonneville will continue its relationship, by then expected to be well established, with the Pacific Northwest Electric Power and Conservation Planning Council. It also will test and operate three MOD-2 wind turbine generators; and will conduct research in ultra-high voltage transmission, new methods of system operation and control, load forecasting techniques, and related areas.

Under Public Law 96-501, Bonneville's current borrowing authority of $1.25 billion was expanded to include not only construction of transmission facilities, but also financial assistance for conservation measures, renewable resources, and fish and wildlife. The Act also increased Bonneville's borrowing authority by an additional $1.25 billion, reserved for the purpose of providing funds for conservation and renewable resource loans and grants. During Fiscal 1983, Bonneville will use its borrowing authority for appropriate program activities.

Although it anticipates power sales of 203 billion kilowatt hours and revenues of $1.7 billion, Bonneville anticipates a net outlay of $300 million with total expenditures of $2 billion. Bonneville is self-financed and requires no appropriations, although Congress has the authority to revise Bonneville's budget submissions through appropriations acts.

Southeastern Power Administration: In Fiscal 1983, Southeastern will have the responsibility to market 3,000 megawatts of Federal power from 21 projects through wheeling arrangements with non-Federal utilities to approximately 250 wholesale customers in 10 states. Energy sales will approximate 6.9 billion kilowatt-hours. Southeastern will continue to develop and implement policy applicable to its four systems designed to achieve the sale of all available power and energy to public bodies and cooperatives. Because sales to non-preference customers will be terminated, net billing procedures will no longer be appropriate requiring appropriations to cover all wheeling and firming expenses. Southeastern will require a budget of $11.8 million in Fiscal 1983, about $10 million of which will be for wheeling charges and purchased power. Rates will be increased to produce $71.7 million in revenues which will include immediate recovery of the appropriated moneys. An increase or decrease in the budget will primarily affect the implementation of the revised contracts for customers in the Georgia-Alabama System of 10 projects. New contracts, to replace contracts

expiring in May of 1983, will implement the new policy of selling all available power to preference customers. The requested budget will require a delay in implementation of the contracts for some two months. An increase or decrease of 10 percent would advance or delay implementation of the new contracts and the additional revenue which would be earned. Southeastern will also seek to reach agreement on wheeling contracts with utilities not now dealing with Southeastern in whose areas new policy proposes sales.

Southwestern Power Administration: In Fiscal 1983, Southwestern will operate and maintain its transmission system at acceptable utility standards and will sell 5.5 billion kilowatt hours. It will study opportunities for interregional interconnections, adjust rates to ensure recovery of costs, and contract for right-of-way and transmission line maintenance on a catch-up basis. It anticipates revenues of $69.1 million. Because 1981 has been a severe drought year, Southwestern has exhausted its carryover purchase power funds. It therefore will need $24.5 million in FY 1983 to ensure the ability to purchase power for five months of a critical water year. An addition of $3.6 million would provide funding for six months of a critical year. A cut of that amount would leave Southwestern with four months of purchased power. The operating budget is $9 million, an increase of $549,000 from FY 1982 because of the addition of a new hydroelectric plant in FY 1983. A further increment of $425,000 would permit a renewable resource program. A decrement would jeopardize operation and maintenance of the transmission system. The construction budget is $4.5 million. A decrement of 10 percent would eliminate the planning and construction of interconnections with the Southwest Power Pool to increase system reliability and provide voltage support and power transfer capability. It also would eliminate a study of Southwestern's communication system which is in need of improvement.

Western Area Power Administration: In FY 1983, Western will operate and maintain 16,000 miles of transmission lines and associated power facilities. It anticipates marketing 3 billion kilowatt hours of energy and receiving revenues of $400 million. Its operations and maintenance budget is $58.2 million which only allows for about 70 percent of scheduled maintenance. A $3.2 million increment would provide for additional employees to perform maintenance on existing and recently completed power systems and for transferred transmission facilities from the Bureau of Reclamation. Any budget reduction would seriously reduce regularly scheduled maintenance work. Western plans a transmission line construction program of $103 million in FY 1983. This will continue the work on Western's program to upgrade and rehabilitate transmission lines, complete the Miles City-New Underwood transmission line, the east-west a.c.-d.c.-a.c. intertie, and advance Federal participation in work on the 345-kV transmission lines in Colorado and New Mexico. These items will require approximately $55.5 million in FY 1983 and will significantly increase Western's capability to generate additional revenues. Reliability additions and improvements at substations including substation work associated with the 345-kV lines in Colorado and New Mexico will be continuing and requires $37.5 million. Construction will also be completed on the new operation and dispatch center at Loveland-Fort Collins as well as on other supervisory control and associated communication equipment and maintenance facilities and requires $10 million. Unlike most units in the Energy Department, Western uses the budget funding concept of "staged construction funding" for anticipated contractor earnings each fiscal year. This process thus has a continuing construction commitment which carries over from year to year. A budget decrement of 10 percent

would defer and stretch out many continuing construction work items and postpone initiation of major transmission upgrades and new energy transfer capability contracts. Western also proposes $51 million for its purchased power and wheeling program. This provides no funding to purchase lower-cost coal-fired power for the Central Valley Project to replace power lost by the expiration of the Centralia contract December 31, 1981. The budget proposes instead to draw down "bank account number one" with the Pacific Gas and Electric Company, which is low cost in the short run but will result in very high cost oil-fired power purchases to meet customer loads when "bank account number two" is used by as early as 1984-1985. Purchasing relatively low-cost surplus energy available in the Wyoming and Montana areas now would have postponed the need to purchase this very expensive oil-fired power. A decrement of $2 million in this program would sacrifice Western's oil conservation program in which it exchanges low-cost hydro on peak for moderate to high cost oil generation. Western expects to save 4 million barrels of oil in FY 1983 and earn revenues in the range of $20 million. Western also asks $500,000 for its emergency fund.

DISCONTINUATION REQUIREMENTS

Bonneville is self-financed and is not dependent upon appropriated funds. Each of the other administrations collects sufficient revenues each year to cover all current costs of operation and maintenance, purchase power and wheeling. No tax dollars are needed to continue electric power service. If appropriations were to be reduced or discontinued for the other power administrations, the most constructive action would be to place them on self-financing, paralleling the Bonneville system to the extent appropriate.

Transition to an alternative delivery organization would be extremely complex. Federal hydroelectric power is sold under long-term contracts primarily to local municipal utilities like the City of Los Angeles and to rural electric cooperatives. Service cannot legally be curtailed with these customers without arrangements being made for an alternative way to deliver the energy and capacity they have agreed to purchase, and without amending or repealing more than 20 separate acts of Congress.

Unless the generating facilities at Federal dams also were sold, disposal of the transmission systems of the power administrations would not alter the need to market Federal hydropower and to price the power to recover the investment in dams and generating equipment, to repay the cost of the power production, and to obtain assistance for irrigation.

Table 1

POWER MARKETING

PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)		Budget Data ($ Millions) Status FY 78	FY 79	FY 80	FY 81	DEGREE ORIGINAL OBJECTIVE MET
See below	None	Alaska BA	$1.736	$2.239	$2.432	$2.854	
		Obligations	1.914	2.376	2.439	3.069	
		Southeastern BA	1.179	1.253	1.400	1.647	
		Obligations	1.009	1.198	1.302	1.616	
		Southwestern BA	25.891	36.077	32.180	28.208	
		Obligations	13.293	20.773	18.671	34.569	
		Western Area BA	93.250	105,738	128.152	142.250	
		Obligations	72.211	71.754	110.979	142.250	est
		Total BA	$122.501	$145.307	$164.392	$175.079	
		Obligations	88.249	95,964	133.364	181.289	
		Bonneville					
		Gross Receipts	$329.759	$390.683	$672.061	$752,000	
		Outlays	382.631	449.820	552.917	772,000	
		Net Outlays	$ 52.872	$ 59.137	$-19.144	$ 20,000	

			PROGRAM MEASURES FY 78	FY 79	FY 80	FY 81	
			(Billions of kilowatt hours)				
1. Market all available power	None	Alaska	.3	.2	.3	.3	Objectives are met each year on a continuing basis.
		Bonneville	76.5	72.0	72.5	81.0	
		Southeastern	7.4	7.6	8.1	5.7	
		Southwestern	5.3	5.8	4.5	3.5	
		Western Area	34.6	36.1	37.9	37.9	
		Total	124.1	121.7	123.3	128.4	

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	Revenues	FY 78	FY 79	FY 80	FY 81	DEGREE ORIGINAL OBJECTIVE MET
			($000,000)				
II. Market at lowest possible cost	None	Alaska	$ 3.2	$ 2.8	$ 3.5	$ 3.7	Objectives are met each year on a continuing basis.
		Bonneville	320.0	308.4	505.0	700.2	
		Southeastern	53.9	58.7	63.7	57.0	
		Southwestern	50.1	60.6	58.8	47.0	
		Western Area	274.0	306.3	330.7	383.8	
		Total	$701.2	$736.8	$961.7	$1,185.5	

Rates per kWh

Alaska	12.5 mills - 15.6 mills
Bonneville	11.5 mills - 34 mills
Southeastern	10 mills
Southwestern	12.7 mills
Western Area	3.5 mills - 17 mills

Cumulative Applications of Revenues in $ Millions Through FY 1980

	Total Revenues	Operating Expenses: OM	Operating Expenses: Purchased Power	Interest	Return of Capital (Power)
Alaska	$ 45	$ 13	$ 2	$ 17	$ 13.
Bonneville	4,442	1,351	727	1,713	651.
Southeastern	869	267	20	336	237.
Southwestern	870	324	206	289	51.
Western Area	3,882	1,359	578	890	1,055
Total	$10,099	$3,314	$1,533	$3,245	$2,007

III. Repayment of Capital — None

Capital Invested and Repaid Through 1980

	Investment on Power ($000): Corps of Engineers	Bureau of Reclamation	Power Administration	International Boundary and Water Commission	Total Power Investment ($000)	Irrigation Investment To Repay ($000)	Total Capital Invested ($000)	Power Investment Repaid ($000)	% Repaid
APA			$ 112,000		$ 112,000		$ 112,000	$ 13,000	11
BPA	$3,232,000	$ 790,000	$ 1,988,000		6,010,000	$ 596,000	$6,606,000	$ 651,000	10
SEPA	$ 999,000				$ 999,000		999,000	$ 237,000	24
SWPA	$ 612,000		$ 66,000		$ 678,000		678,000	$ 48,000	7
WAPA	$ 651,000	$ 2,265,000	$ 707,000	$ 7,000	$ 3,630,000	$ 776,000	4,406,000	$1,055,000	27
Total	$5,494,000	$ 3,056,000	$ 2,873,000	$ 7,000	$11,429,000	$1,372,000	$12,801,000	$2,003,000	

IV. Preference to public bodies and cooperatives	None	Number of Preference Customers Served	FY 78	FY 79	FY 80	FY 81	Public preference mandate is fully met each year
		Alaska	4	4	4	4	
		Bonneville	116	116	116	116	
		Southeastern	192	191	191	190	
		Southwestern	56	49	51	51	
		Western Area	444	444	444	444	
		Total	812	804	807	807	

95-882 O—82——55

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)						DEGREE ORIGINAL OBJECTIVE MET
			Proportion of Energy Sold in 1980 to Preference Customers				
			Alaska	70			
			Bonneville	82			
			Southeastern	98*			
			Southwestern	90			
			Western Area	82.5			
			*Includes TVA				
			PROGRAM MEASURES				
			FY 78	FY 79	FY 80	FY 81	
			Miles of Line Maintained				
V. Construct and operate transmission lines	None	All PMAs	29,000	30,000	30,200	30,500	All Goals/Objectives are met each year on a continuing basis.
			Miles of Line Constructed				
		Bonneville	92	181	179	873 (est)	
		Western	0	182	0	150 (est)	
			Substations Constructed				
		Bonneville	6	3	7	9 (est)	
		Western	1	3	4	2 (est)	
VI. Market power over large areas at common rates	None	Alaska	Eklutna rate uniform in sales area Snettisham rate uniform in sales area				Met each year on a continuing basis.
		Bonneville	System-wide				
		Southeastern	Uniform rates in each major marketing area: Georgia-Alabama; Kerr-Philpott; Cumberland. Separate rates for Jim Woodruff and Laurel projects.				
		Southwestern	System-wide rate. Sam Rayburn Project				
		Western Area	Uniform rates in each major marketing area: Missouri Basin Project, Colorado River Storage Project, Central Valley Project, Parker-Davis Project. Separate rates for several individual projects. Boulder Canyon, Rio Grande, Fryingpan-Arkansas, Collbran.				

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)		PROGRAM MEASURES FY 78	FY 79	FY 80	FY 81	DEGREE ORIGINAL OBJECTIVE MET
			Ellamatt Hours Produced				
VII. Operate and maintain Eklutna and Snettisham Generating Station	None	Alaska	276	238	293	297	Met each year on a continuing basis.
			Studies Completed				
VIII. Conduct general investigations	None	Alaska	5	6	14	13	Met each year on a continuing basis
IX. Acquire resources to meet Administrator's net obligations	State and Local Private	Bonneville	N/A	N/A	N/A	Not yet available	New program under P.L. 96-501
			Dollars Invested ($000)				
X. Protect, enhance, mitigate fish and wildlife	DOI Fish & Wildlife Service	Bonneville	$500	$1,300	$1,400	$2,800 (est)	New program under P.L. 96-501
			Projects Initiated				
	DOC NOAA State and Fish and Game Commission	Bonneville	3	6	2	7 (est)	

TABLE 2

POWER MARKETING

CURRENT PROGRAM OBJECTIVES AND BUDGET
(Budget data in FY 1982 dollars, millions)

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS FOR OBJECTIVE (TARGET DATE)		BUDGET JUSTIFICATION & SERVICES REQUIRED		
				FY 82	FY 83	FY 84 - FY 87
I. Market all available power	Sell falling water Non-federal development of hydro Would require change in law	Contracts with preference customers through rest of 20th century	APA	$ 3.5	$ 3.6	$ 11.9
			SEPA	7.2	11.8	114.8
			SWPA	21.3	38.1	150.2
			WAPA	211.3	246.4	1,681.0
				$243.3	$299.9	$1,957.9
			BPA	$ 25.0	$300.0	$ 880.0
				To market power from 122 federal multiple-purpose projects, to operate and maintain 30,000 miles of transmission lines and associated facilities, and to construct needed additions and replacements. Continuing operations in future years will rise in costs with inflation and higher costs of capital investments.		
II. Market at lowest possible price to recover expenses	Sell at marginal cost; sell at market price Would require change in law	Rate increases as necessary by each power administration		Revenues anticipated in millions:		
				FY 82	FY 83	
			APA	$ 4.0	$ 4.5	
			BPA	1,579.6	2,223.3	
			SEPA	65.7	71.7	
			SwPA	70.8	69.1	
			WAPA	370.5	400.0	
				$2,108.1	$2,771.6	

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS FOR OBJECTIVE (TARGET DATE)	BUDGET JUSTIFICATION & SERVICES PROVIDED
III. Repayment of Capital Investments	Not applicable	Required by law	No budget required. Estimated repayment FY 82 ($000) / FY 83 ($000) APA 1,034 / 1,258 BPA N/A / N/A 1) SEPA 17,000 / 17,600 SWPA 10,500 / 10,500 WAPA 86,561 / 126,053
IV. Preference to public bodies and cooperatives	None	Allocations of new power and some reallocations of existing power to serve preference customers by each PMA	See Item I
V. Construct and operate transmission lines and substations	Seek wheeling by non-Federal utilities	Additions, rehabilitation, upgrading to improve reliability Interregional interconnections	Construction only 1) FY 82 ($000) / FY 83 ($000) APA $ 0 / $ 0 BPA 190,000 / 282,000 SCPA 0 / 0 SWPA 3,538 / 4,530 WAPA 101,400 / 112,000 $294,938 / $310,530

1) Figure unavailable pending knowledge of actual revenue and expense amounts at year end.
2) Contained within total budget numbers in Topic I.

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS FOR OBJECTIVE (TARGET DATE)	BUDGET JUSTIFICATION & SERVICES PROVIDED
			Operation and Maintenance 1) FY 82 ($000) / FY 83 ($000) APA $ 1,987 / $ 2,187 BPA 83,300 / 94,605* SEPA 7,200 / 11,800 SWPA 8,521 / 9,070 WAPA 56,174 / 61,400 *Bonneville is self-financed See Item 1
VI. Market power over large areas	Market to nearest preference utilities	Consolidation of some isolated projects by SWPA, WAPA	See Item I above
VII. Operate and maintain Eklutna and Snettisham generating stations	None	Continue full range of annual maintenance and operation activities and replacements and improvements as needed and justified	FY 82 ($000) / FY 83 ($000) APA Included in O&M budget above.
VIII. Conduct general investigations	Increase non-Federal investments in investigations	Transmission, power marketing and operation and maintenance studies for hydro projects investigated by Corps; investigation of renewable resource alternatives and energy efficiency options.	FY 82 ($000) / FY 83 ($000) APA $893 / $803
IX. Acquire resources to meet Administrator's obligations	States Non-Federal Utilities Private efforts Acquire additional energy and capacity	Estimated rate of energy savings by 1987: Annual Avg MW 1110 MW	FY 82 ($000) / FY 83 ($000) BPA $261,000 / $480,000
X. Protect, enhance, mitigate fish and wildlife	DOI Fish & Wildlife Service State Fish and Games Commission	N/A	FY 82 ($000) / FY 83 ($000) BPA $4,200 / $5,200

much greater than the funds awarded by DOE. Just two of the grantees are already employing 300 more people than prior to their grant awards. Three others have created an equal number of jobs for either their industry or their licensees. 4) A study of the program by the Massachusetts Institute of Technology concluded that the Inventions Program provides one of the few funding channels through which inventors can receive an objective hearing. They also found that a significant number of valuable ideas have been submitted to the program and "that the societal returns on those that eventually come into public use appears likely to repay the Nation manyfold." 5) As has become evident from the program, retaining the entrepreneur is frequently the single most important thing to do so far as insuring the product reaches the marketplace. Program support has helped, and sometimes has enabled, the entrepreneurs it supports to maintain their proprietary positions.

The historical precedence is that most innovative new ideas and inventions for use in the private sector have come from the small businessman and the individual inventors, and the program is tapping that resource. However, it should also be considered that market penetration is a laborious process, and normally takes 6 to 8 years. The program has existed less than that interval. It is small in size and, to accommodate the funds available, has a policy of one-time-only assistance. Its national impact should be measured accordingly.

PROJECTED PROGRAM REQUIREMENTS: The private sector can not now provide the necessary financial or technical support at the significant levels required for the development of any large number of high-risk energy-saving technologies. There is an inherent lack of incentives, to both the entrepreneur and the funding agency, for any significant level of support to occur on an ad hoc basis. Entrepreneurs typically advise that funding from the private sector is generally not available until the product stage has been reached and the company is operating successfully. The Program need to support innovative ideas from the individual and small business can therefore be expected to continue until incentives develop for the private sector to take an active role.

DISCONTINUATION REQUIREMENTS: Phase out of the Energy-Related Inventions Program would require the amendment of Section 14 of P.L. 93-577, and the orderly phasing out of Program activities. A significant level of Program activity could not be maintained by transfer of activities to other DOE program offices, except at a higher cost of dollars/staff of handling these inventions on a decentralized basis, and at a cost of disruption to the more normal type of program activities. Most of the NBS-recommended inventions received to date have some inherent conflicts, or a lack of fit, with other DOE program areas in which they fall. The private sector could conceivably assume responsibility for the Program, and probably could make it viable, if a willing "champion" could be found for it. There are some potential incentives that could develop for this to happen, and there has been some tenative expressions of preliminary interest. Also, the program could fit within the Department of Commerce because of its activities in the field of diffusion of innovation and entrepreneurship, and its potentials especially in the industrial sector for increasing the Nation's productivity.

APPROPRIATE TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES: The Appropriate Technology Program serves as a focal point in the Department for supporting the efforts of small businesses and individuals

in the development and demonstration of small-scale technologies that conserve energy and/or use renewable forms of energy. Congress authorized its establishment under the Energy Research and Development Administration Appropriation Authorization of 1977 (PL 95-39).

The overall goal of the Appropriate Technology Program is to promote the development and demonstration of and the dissemination of information with respect to small-scale, decentralized renewable energy systems that are environmentally sound; use locally available material; are simple to install, operate, and maintain; satisfy local needs; and decrease community dependence on external energy sources.

The objectives of the program are to identify the promising projects of small business and individuals and provide the necessary financial and technical support to further the concept development, device development, or demonstration of new or innovative small-scale, decentralized, and renewable energy technologies and to promote the diffusion of these technologies by disseminating information on successful, completed projects so that these may have widespread replication.

Since FY 1978, the first year of the program, nearly 45,000 proposals were evaluated, and, of these, an estimated 2,400 (5 percent) were selected for funding at a cost of $28 million. Approximately 20 publications have been released and about 50 technology transfer events (e.g., workshops) have been conducted to encourage the replication of successful projects.

PROGRAM IMPACTS: The program has met its objective of supporting the RD&D of small-scale, decentralized renewable energy technologies by providing necessary financial assistance to approximately 2,400 projects nationwide since FY 1978. However, as a result of budget limitations, no technical assistance could be made available. Due to the time lag of receiving information from completed projects and the premature termination of the program, only limited progress was achieved in meeting the program objective of encouraging the replication of successful projects through the dissemination of information.

An energy impact study of the FY 1979 program by the Lawrence Berkeley Laboratory (LBL) concluded that those projects funded in FY 1979 could save 22.8 million barrels of oil equivalent (BOE) of energy over the lifetimes of the projects and replicated systems; the program can save annually 1.2 million BOE of energy by 1985 just through projects funded in FY 1979; using a conservative approach, between 1,190 and 4,520 BOE energy savings will be made per $1,000 of DOE funding through the Appropriate Technology Program; using the same approach, the cost to DOE for each BOE produced ranged from $0.20 to $0.85 each.

Principal beneficiaries of program assistance have been individuals, small businesses and Indian tribes who have clearly demonstrated historically, a great capacity for productive innovation but have faced certain unique economic disadvantages in obtaining private sector support for their ideas.

The program has also served to increase public awareness of conservation and small-scale, renewable energy technologies through the encouragement of community involvement in demonstration projects that could also serve to reduce the impact of increased energy costs on the less affluent segments of the American population.

Since projects funded under this program are small in scale, seek to conserve non-renewable resources, use renewable resources, and are designed to be environmentally sound, the negative potential environmental, health, and safety impacts of the program can be characterized as insignificant.

DISCONTINUATION REQUIREMENTS: This program has already been terminated, and FY 1981 will be the last grant award cycle. Since projects are funded at the end of the fiscal year for up to twenty-four months, all project activity will not cease until FY 1984. As a result, some technology transfer and information dissemination activities would continue through at least the end of FY 1984, and for some projects which produce a demonstration product, perhaps much longer. It is estimated that a budget of approximately $5 million would be required for each of the Fiscal Years 1982-84 to achieve a minimum level of program benefit through providing information to the public on successful projects already funded to allow for replication of these projects through private funding.

TABLE 1a.

MULTI-SECTOR CONSERVATION

ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES

PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (Duplicative)	BUDGET DATA ($ THOUSANDS) / STATUS FY 78 0 FY 79 0 FY 80 0	FY 81* 3,000	SHOWS ORIGINAL OBJECTIVE MET
Expand the technology base available to the private sector for the development of improved energy systems and devices, and evaluate new or innovative concepts for improved efficiency or alternative fuel use in energy conversion or utilization systems.				
• To develop by 1986, validated integrated system models for three innovative internal combustion engine concepts, namely, Direct Injection Stratified Charge (DISC), Dilute Homogeneous Charge (DHC), and Diesel Engines, for use by industry in designing engines which are 20 to 30% more efficient than currently used ones.	Automobile manufacturers conduct engine research; to avoid duplication, this program is conducted on a co-op (non-funded) basis with auto industry representation.		Completed development and verification of intake process models for Direct Injection Stratified Charge (DISC) and Dilute Homogeneous Charge (DHC) engine concepts.	Development and verification of models of intake, fuel preparation and exhaust processes for DISC, DHC and diesel engine concepts to be completed by March 1982.
• To develop by 1989, advanced concepts and analytical methods for use by industry in designing Stirling, Rankine, and Brayton Cycle Power Systems whose efficiencies are at least 10% better than currently used technologies.	Other DOE offices conduct Stirling engine research through ANL; Sweden, Holland & England do similarly. ECUT Stirling research is executed via ANL to assure it is supportive of rather than redundant of that on-going. To avoid duplication of foreign research, ECUT, will manage IECEC sessions detailing activities in the field.		Assessment of technology needs for Stirling Engine Technology completed.	Research priorities for enhanced development of Stirling Engine Technology to be established by January 1982.
• To develop by 1986, computerized data bases and experimentally validated models for use by industry in designing innovative, more reliable, industrial heat exchangers which are at least 10% more effective than 1980 state-of-the-art equipment.	Assignment of this research to ID/RCG assures the research is complimentary to DOE, IEA, and Fossil Energy (DOE) sponsored research.		Data accumulation on flow induced vibration (FIV) in industrial shell-and-tube heat exchangers analyzed.	Computerized data bases and models to be completed by 1986.
• To generate data and develop techniques by 1989, which could lead to engineering of bulk chemical feedstocks and commodities production that require 50% less energy than currently used processes.	Research agenda is currently being drafted and a key criterion for work element inclusion in the agenda is that efforts be non-duplicative of on-going public or private sector research.		Research agenda for Chemical Process Project established.	Low Temperature and pressure biocatalyzed processes to be developed by 1987.

* FY 1981 is the first year of the program.

TABLE 1b.

MULTI-FACTOR CONSERVATION

ENERGY-RELATED INVENTIONS PROGRAM

PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (DUPLICATIVE)	BUDGET DATA ($ MILLIONS) / STATUS				BRIEFLY ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
		3,325	4,222	6,400	5,800	
• To evaluate the technical merits of all submitted energy-related inventions	none	inventions evaluated				As many inventions annually are being evaluated as are being submitted.
		3,437	2,713	3,292	1,472	
• To provide assistance for the R&D of energy-related inventions by individuals and small businesses		inventions funded by grants/ grant funding costs				For NBS, every invention submitted is receiving an evaluation. For DOE, the goal of assisting each inventor being recommended is being achieved, within limits of the available resources.
		22	35	23	35*	
		1,375	2,322	1,956	3,019	
• To encourage inventors and innovation through information dissemination.		number of workshops held/number of publications distributed				The goal of workshops within easy travel distance of anyone in the United States who might be interested is being achieved.
		0	0	6	4	
		30K	30K	210K	150K	
• To conduct a cost effective system of technical and progress monitoring of funded inventions.		0	0	0	148K	Based upon an independent assessment of program functions and needs, OHER, as contractor to the program will provide and maintain the subject monitoring system. The monitoring is underway and results will be available in February 1982.

* Includes 26 grants in the DOE Procurement System as of 7/1/81.

TABLE 1c.

MULTI-SECTOR CONSERVATION

APPROPRIATE TECHNOLOGY SMALL GRANTS PROGRAM

PROGRAM ACCOMPLISHMENTS

GOALS/OBJECTIVES	OTHER PROGRAMS (IMPLICATIVE)	BUDGET DATA ($ MILLIONS) / STATUS				INDICES ORIGINAL OBJECTIVE MET
		FY 78	FY 79	FY 80	FY 81	
		1.2	10.7	12.9	12.0	
o To support the R&D of small-scale, decentralized renewable energy technologies	o Energy-Related Inventions Program	1,110	Proposals Evaluated 12,876	19,462	11,059	
		100	Projects Funded 584	856	850 (est.)	Provide necessary financial assistance to multi-sectoral technology development on national scale. No technical assistance was made available.
o To encourage the replication of successful projects through the dissemination of information.			Final Reports Available 150 (est.)			Project results are now beginning to be submitted. Only minor efforts to date in this area.

TABLE 2a

ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES

CURRENT PROGRAM OBJECTIVES AND BUDGET

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS (for objective target date)	BUDGET JUSTIFICATION AND SERVICES PROVIDED[a]
Expand the technology base available to the private sector for the development of improved energy systems and devices, and evaluate new or innovative concepts for improved efficiency or alternative fuel use in energy conversion or utilization systems.	• Rely on private sector. However historically, private sector R&D is largely on product development and market research. • Rely on foreign developed technology. This leads to loss of competitiveness of U.S. industry • Rely on Federally-supported non-energy R&D. Energy use efficiency improvements will only be accidental to objective of the research, hence, not assured.		Budget FY 1982 $12M FY 1983 $ 6.5M Estimated Outyear Costs $30M
• To develop by 1986, validated integrated system models for two innovative internal combustion engine concepts, namely, Dilute Homogeneous Charge (DHC) and Diesel engines, for use by industry in designing engines which are 20 to 30% more efficient than currently used ones.		• Increased capability for engine combustion analysis. Leads to better engine designs of improved efficiency and decreased pollutants.	• Large-scale multidimensional computer model of engine intake process completed by 1982. • Model for open-cycle engine processes from intake to exhaust completed by 1983.
• To develop by 1986, computerized data bases and experimentally validated models for use by industry in designing innovative, more reliable, industrial heat exchangers which are at least 10% more effective than state-of-the-art equipment.		• More effective heat exchangers to improve utilization of energy.	• Design methodology for avoidance of flow induced vibration failure in shell-and-tube heat exchangers provided by 1983. • Data accumulated on fouling of heat transfer surfaces by industrial process exhaust streams analyzed by 1984.
• To generate data and develop techniques by 1989, which could lead to engineering bulk chemical feedstocks and commodities production that require 50% less energy than currently used processes.		• More energy efficient chemical processes and techniques.	• Methodology for engineering design of stable support structures for enzymes useful to industry in biocatalyzed processes developed by 1984. • Methodology for engineering design of low temperature, low pressure, continuous processes developed by 1985.

[a] Detailed justification in FY 1983 Congressional Budget submission.

APPENDIX III

ADDITIONAL MATERIAL SUBMITTED BY MEMBERS AND WITNESSES FOR THE RECORD

ORNL/TM-7690/V1

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OAK RIDGE NATIONAL LABORATORY

UNION CARBIDE

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Energy Saving Impacts of DOE's Conservation and Solar Programs

(An ORNL/MITRE Study Performed in 1980)

Volume 1
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ORNL/TM-7690/V1

Contract No. W-7405-eng-26

ENERGY DIVISION

ENERGY SAVING IMPACTS OF DOE's CONSERVATION AND SOLAR PROGRAMS

(An ORNL/MITRE Study Performed in 1980)

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CONTENTS

Volume 1

	Page
SPONSORSHIP AND ACKNOWLEDGMENTS	xiii
ABSTRACT	xv
1. EXECUTIVE SUMMARY	1-1
2. ANALYSIS OVERVIEW	2-1
2.1 Policy Planning and Evaluation Function of DOE's Office of Conservation and Solar Energy	2-1
2.2 ORNL/MITRE Study: Combining Computer Model Analyses with Policy Analyst Judgments	2-1
2.3 Key Features of the ORNL/MITRE Study	2-2
2.4 Overview of Baseline Analysis	2-5
2.5 Program Impact Assessments	2-13
2.5.1 Scope of ORNL/MITRE assessments	2-13
2.5.2 Impacts of individual program elements	2-16
2.5.3 Joint impacts of program element groupings	2-17
2.6 Analysis of Results	2-30
2.6.1 Overall implications of ORNL/MITRE estimates	2-30
2.7 Study Caveats	2-36
REFERENCES FOR SECTION 2	2-44

Volume 2

SPONSORSHIP AND ACKNOWLEDGMENTS	xxv
ABSTRACT	xxvii
3. HISTORICAL TRENDS IN U.S. ENERGY CONSUMPTION	3-1
3.1 Introduction	3-1
3.2 Overall History of Energy Use	3-1
3.3 Residential and Commercial Buildings	3-8
3.4 Transportation Sector	3-12
3.5 Industrial Sector	3-18
REFERENCES FOR SECTION 3	3-23
4. BUILDINGS AND COMMUNITY SYSTEMS	4-1
4.1 Introduction	4-1
4.2 Single-Buildings Conservation-Policy Modeling Capabilities in the Buildings Sector	4-2
4.2.1 Introduction	4-2
4.2.2 Structure of the ORNL models	4-2
4.2.3 Generic conservation program representation	4-6
4.3 Baseline Scenario and Associated Conservation	4-8

95-882 O—82——56

		Page
4.4	Representation of Conservation Program Elements	4-9
4.4.1	Building systems	4-9
4.4.2	Technology and consumer products	4-11
4.4.3	Residential conservation service	4-12
4.4.4	Appliance standards	4-12
4.4.5	Analysis and technology transfer	4-12
4.4.6	Weatherization	4-12
4.4.7	Federal energy management	4-13
4.4.8	Hospital and school grants	4-13
4.4.9	Proposed commercial building retrofit program	4-13
4.5	Energy-Use and Savings Estimates of Conservation Program Elements	4-14
4.6	Analysis of Community Systems Program Element	4-21
4.6.1	Introduction	4-21
4.6.2	Baseline analysis (no community systems programs)	4-22
4.6.3	Basic level funding analysis	4-23
4.6.4	Enhanced funding level analysis	4-27
4.6.5	Conclusions	4-29
4.7	Areas for Improvement of Estimates	4-30
4.8	Bibliography	4-33
4.8.1	Residential- and commercial-sector model documentation	4-33
4.8.2	Community systems documentation	4-33
REFERENCES FOR SECTION 4		4-33
5.	INDUSTRY	5-1
5.1	Introduction	5-1
5.2	Baseline Scenario Development	5-2
5.2.1	Introduction	5-2
5.2.2	Capabilities of ORIM	5-2
5.2.3	Structure of ORIM	5-3
5.3	Policy Analysis	5-6
5.3.1	Policies affecting operating costs	5-7
5.3.2	Policies affecting investment costs	5-8
5.3.3	Regulatory policies	5-9
5.3.4	Limitations of ORIM in policy analysis	5-9
5.4	Scenario Assumptions and Model Application	5-10
5.4.1	Manufacturing sector	5-10
5.4.2	Nonmanufacturing industries	5-14
5.5	Baseline Projections	5-20
5.6	Program Impact Analysis	5-21
5.6.1	Introduction	5-21
5.6.2	Overall energy and petroleum savings	5-24
5.6.3	Program assumptions	5-36
5.7	Areas for Methodological Improvement	5-36
5.7.1	Forecasts	5-36
5.7.2	Energy savings impact estimation	5-36
REFERENCES FOR SECTION 5		5-40

		Page
6.	TRANSPORTATION	6-1
	6.1 Baseline Scenario Development	6-1
	6.1.1 Introduction	6-1
	6.1.2 Model capabilities	6-1
	6.1.3 Modal forecasting assumptions and model applications	6-5
	6.1.4 Baseline forecasts	6-43
	6.1.5 Summary	6-59
	6.2 Policy Analysis Scenarios	6-60
	6.2.1 Introduction	6-60
	6.2.2 Overall energy- and petroleum-saving impacts	6-61
	6.2.3 Transportation program success assumptions	6-63
	6.2.4 Energy and petroleum savings by mode and fuel type	6-66
	6.2.5 Summary	6-73
	6.3 Areas for Methodological Improvements	6-74
	6.3.1 Forecasting	6-74
	6.3.2 Energy-saving impacts estimation	6-74
	6.3.3 Level of budget analysis	6-75
	REFERENCES FOR SECTION 6	6-76
7.	SOLAR	7-1
	7.1 Introduction and Background	7-1
	7.1.1 Scope	7-1
	7.1.2 Scenario description	7-2
	7.1.3 Summary results	7-3
	7.2 Model Capabilities	7-5
	7.2.1 Overview of the model	7-12
	7.2.2 Buildings component	7-17
	7.2.3 Industrial applications	7-23
	7.2.4 Utility component	7-26
	7.2.5 Regional analysis	7-31
	7.3 Model Adjustments for Existing Legislation	7-32
	7.3.1 Utility and synthetic products market sector	7-34
	7.3.2 Residential and commercial sector	7-36
	7.3.3 Industrial sector	7-37
	7.4 Scenario Assumptions	7-39
	7.4.1 Utility and synthetic products	7-39
	7.4.2 Scenario data — residential and commercial sector	7-43
	7.4.3 Fuel price and economic assumptions — industrial sector	7-48
	7.5 Results	7-53
	7.5.1 Utility sector	7-53
	7.5.2 Synthetic products sector	7-60
	7.5.3 Residential and commercial sector	7-66
	7.5.4 Industrial sector	7-87
	7.6 Recommendations	7-99
	REFERENCES FOR SECTION 7	7-101

		Page
8.	ENERGY STORAGE SYSTEMS	8-1
8.1	Introduction and Summary	8-1
8.1.1	Study background and scope	8-1
8.1.2	General study approach	8-1
8.1.3	Summary of results	8-3
8.2	Electric Vehicles	8-6
8.2.1	Commercialization scenarios	8-6
8.2.2	Energy and fuel impacts	8-6
8.2.3	Economic impacts	8-9
8.3	Load-leveling Batteries	8-10
8.3.1	Commercialization scenarios	8-10
8.3.2	Energy and fuel impacts	8-12
8.3.3	Economic impacts	8-12
8.4	Photovoltaic Batteries	8-12
8.4.1	Commercialization scenarios	8-12
8.4.2	Energy and fuel impacts	8-16
8.4.3	Economic impacts	8-16
8.5	Thermal Energy Storage	8-19
8.5.1	Commercialization scenarios	8-19
8.5.2	Energy and fuel impacts	8-19
8.5.3	Economic impacts	8-22
8.6	Mechanical Energy Storage	8-26
8.6.1	Commercialization scenarios	8-26
8.6.2	Energy and fuel impacts	8-29
8.6.3	Economic impacts	8-29
9.	ENERGY MANAGEMENT PARTNERSHIP ACT (EMPA)	9-1
9.1	EMPA Program Analysis	9-1
9.2	Program Effectiveness	9-4
9.3	Evaluation, Methodology, and Caveats	9-7
9.3.1	FY 82 EMPA funding and administration	9-8
9.3.2	Methodology	9-10
9.3.3	Caveats, energy savings estimates	9-20
Appendix A.	EXISTING ENERGY LEGISLATION	A-1
A.1	Existing Legislation	A-3
A.2	Summaries of Energy-Related Laws	A-12
A.3	Summaries of Executive Orders, Proclamations, and Rules	A-46
A.3.1	Executive orders	A-46
A.3.2	Proclamations	A-49
A.3.3	Final rules for state energy conservation plans as required by EPCA and ECPA	A-50
Appendix B.	RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROJECTS INCLUDED IN THE OIP PROGRAM ANALYSIS	B-1

		Page
Appendix C.	REGIONALIZATION OF TRANSPORTATION SECTOR INPUTS . . .	C-1
	C.1 Regionalization Procedure	C-3
	C.2 Tabulations of Projected State Level Exogenous Variables for the ORNL Highway Gasoline Demand Model	C-6
	C.3 Tabulations of Projected State Gasoline Prices for the ORNL Highway Gasoline Demand Model	C-33
	REFERENCES FOR APPENDIX C	C-37
Appendix D.	NATIONAL SOLAR LEGISLATION	D-1
Appendix E.	THE ENERGY MANAGEMENT PARTNERSHIP ACT (EMPA) AND RELATED ACTS	E-1
	E.1 EMPA Summary	E-3
	E.2 Federal Acts Related to EMPA	E-4
	E.2.1 Energy Policy and Conservation Act . . .	E-4
	E.2.2 Energy Conservation and Production Act (ECPA)	E-6
	E.2.3 National Energy Extension Service Act (NEESA)	E-7
	E.2.4 Emergency Energy Conservation Act	E-8

LIST OF FIGURES

Volume 1

Figure		Page
1.1	Aggregate energy impacts of analyzed sectoral and cross-sectoral programs	1-2
1.2	Baseline energy-use projections (1 x 10^{15} Btu primary energy equivalent	1-5
1.3	Energy-use projections under the program impact analysis scenario (1 x 10^{15} Btu primary energy equivalent)	1-6
1.4	Baseline energy-use projections (1 x 10^{15} Btu primary energy equivalent)	1-8
1.5	Energy-use projections under the program impact analysis scenario (1 x 10^{15} Btu of primary energy equivalent) . . .	1-9
2.1	Organization of conservation and solar energy, U.S. Department of Energy (as of March 17, 1980)	2-14

LIST OF TABLES

Volume 1

Table		Page
1.1	Summary of baseline scenario macroeconomic and macroenergy specifications	1-4
2.1	ORNL/MITRE Study: computer models used	2-4
2.2	Summary of baseline scenario macroeconomic and macroenergy specifications	2-6
2.3	Baseline energy-use projections from Oak Ridge models	2-9
2.4	Baseline solar projections (including fuel displacements)	2-10
2.5	Key missing data in ORNL/MITRE sectoral baseline analysis	2-11
2.6	Energy consumption summary under baseline scenario	2-12
2.7	Program element coverage	2-18
2.8	Energy impacts of individual program elements	2-20
2.9	Aggregation map for program element groupings	2-23
2.10	PIAS energy-use projections from Oak Ridge models	2-24
2.11	PIAS solar projections (including fuel displacements)	2-25
2.12	Energy consumption summary under program impact analysis scenario	2-26
2.13	Estimated aggregate sectoral conservation and solar effects of analyzed program elements	2-27
2.14	Estimated aggregate fuel savings and solar use increments due to analyzed programs	2-28
2.15	Disaggregation of oil savings into conservation and solar effects	2-29
2.16	Summary of energy and oil impacts of DOE/CS's sectoral and cross-sectoral program groupings	2-31
2.17	Time profiles of aggregate energy impacts	2-32

Table		Page
2.18	Sectoral impacts on fossil plus nuclear use, electricity use, and solar use of analyzed sectoral programs	2-33
2.19	Oil and gas saving impacts of analyzed sectoral programs	2-36
2.20	Present value of oil savings and oil and gas savings from analyzed DOE/CS's sectoral programs	2-37

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Especially, due to the nature of this study, it is important to record the support of DOE/CS management and many program office representatives. Many of them participated in the numerous discussions and interactions involving them, the OPPE/CS staff, and the ORNL/MITRE analysts. They also provided critical review and suggestions for improving the earlier draft of the report published on July 11, 1980.

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ABSTRACT

The ORNL/MITRE study was commissioned to assess the energy-saving (displacing) and oil-saving impacts of the Department of Energy's conservation and solar programs. Although it was a coordinated modeling and analysis exercise that employed ORNL's existing computer models of energy use and MITRE's computer models for assessment of solar technology penetrations, it also involved an important participation by the planning staff and the program office representatives of Conservation and Solar Energy, the Department of Energy.

The ORNL/MITRE team analyzed most, but not all, of the DOE's conservation and solar programs. Energy and oil impacts were estimated under a common set of assumptions concerning rising energy prices and economic growth. This report documents the analysis performed and the results obtained.

The study results show that the impacts of analyzed programs are very significant and rise over time. In the year 2000, for example, the analyzed programs are estimated to reduce primary energy consumption by 11%, increase solar use by 36%, and reduce the combined fossil and nuclear use by 16% from the baseline projection that explicitly excluded these programs.

More significantly, the analysis showed that the oil savings are high. For example, at $40/barrel the present value of estimated oil savings for the 1980-2000 period is over $200 billion when discounted at a real rate of 3% per year and over $110 billion when discounted at a real rate of 8% per year.

Recognizing that many recipients may not be interested in all the details of the material presented and to achieve cost-effective distribution, this report is being issued in two volumes:

Volume I: Executive Summary and Analysis Overview (about 60 pages)

Volume II: Historical Trends, Details of Sectoral Analysis, and Appendixes (about 600 pages)

Volume I is self-contained and covers the entire study. It is expected that many readers will find it sufficient for their use. Those more closely involved in the subject matter as well as those interested in pursuing the details of the study may wish to obtain a copy of Volume II.

1. EXECUTIVE SUMMARY

The ORNL/MITRE study was commissioned to assess the energy-saving (displacing) and oil-saving impacts of the Department of Energy's conservation and solar programs. Although it consisted primarily of a coordinated modeling and analysis effort of a team of ORNL/MITRE analysts, it also involved an important participation by the planning staff and the program office representatives of Conservation and Solar Energy, the Department of Energy.

A significant feature of the study is that the energy and oil impacts of the federal programs were estimated within the context of a baseline (reference) detailed set of energy-use and solar technology penetration projections. These projections were developed with ORNL's computer models of energy use and MITRE's computer models for assessment of solar technology penetrations. The models were operated under a common set of assumptions concerning rising energy prices and economic growth.

The ORNL/MITRE team analyzed most, but not all, of DOE's conservation and solar programs. The study results show that the impacts of analyzed programs are very significant and rise over time. In the year 2000, for example, the analyzed programs are estimated to reduce the primary energy consumption by 11%, increase the solar use by 36%, and reduce the combined fossil and nuclear use by 16% from the baseline projection.

More significantly, the analysis showed that the oil savings are high. For example, at $40/barrel the present value of estimated oil savings over the 1980-2000 period is over $200 billion when discounted at a real rate of 3% per year and over $110 billion when discounted at a real rate of 8% per year.

Aggregate energy impacts of analyzed sectoral and cross-sectoral programs are shown in Fig. 1.1. As given, the aggregate effect of the analyzed sectoral conservation and solar programs is:

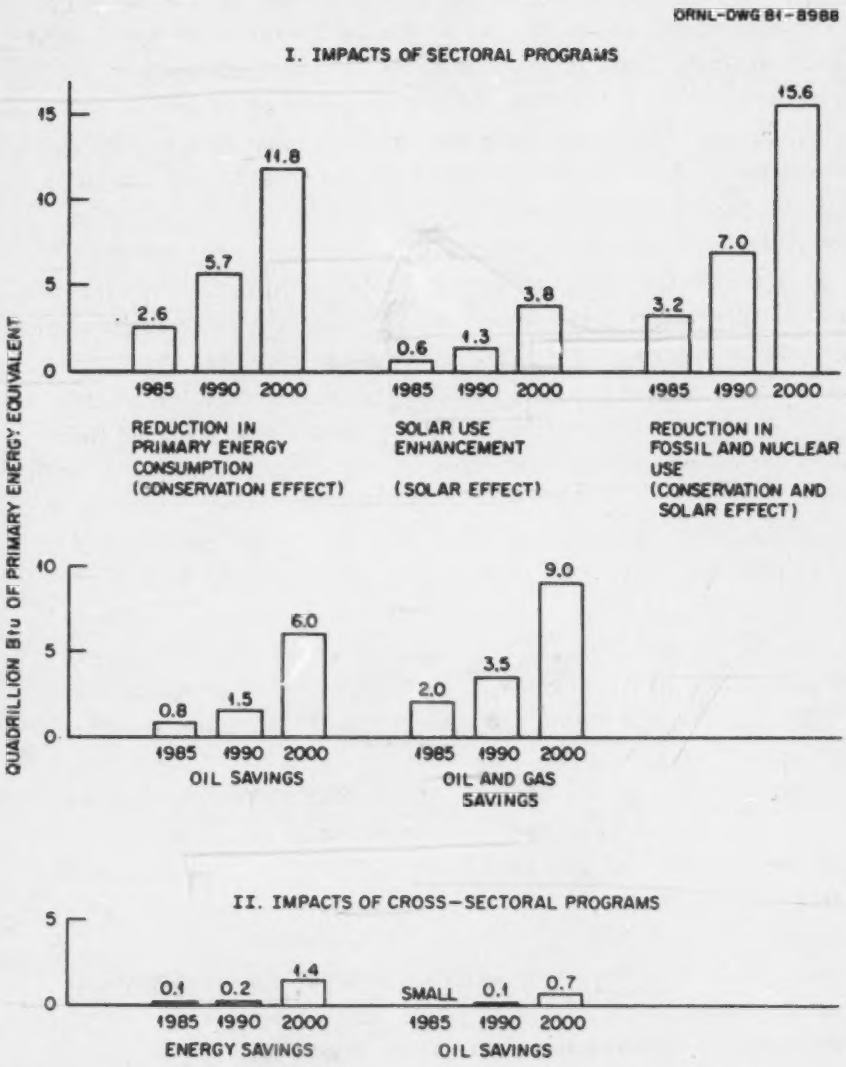

Fig. 1.1. Aggregate energy impacts of analyzed sectoral and cross-sectoral programs.

- to reduce the primary energy consumption by 2.6 quads in 1985, 5.7 quads in 1990, and 11.8 quads in 2000 (conservation effect);
- to increase the solar use by 0.6 quad in 1985, 1.3 quads in 1990, and 3.8 quads in 2000 (solar effect);
- to reduce the fossil and nuclear use by 3.2 quads in 1985, 7.0 quads in 1990, and 15.6 quads in 2000 (combined conservation and solar effect).

With regard to oil and gas savings, the ORNL/MITRE estimate is that these programs will:

- bring about oil savings in the amounts of 0.8 quad in 1985, 1.5 quads in 1990, and 6 quads in 2000;
- bring about oil and gas savings in the amounts of 2.0 quads in 1985, 3.5 quads in 1990, and 9.0 quads in 2000.

Separately, the analyzed cross-sectoral programs are estimated:

- to reduce the primary energy consumption by 0.1 quad in 1985, 0.2 quad in 1990, and 1.4 quads in 2000;
- to save 0.1 quad of oil in 1990 and 0.7 quad of oil in 2000.

The estimates and related details were developed by the ORNL/MITRE analysts, using scenario analyses. The baseline scenario included macroeconomic and fuel price assumptions of Table 1.1 as well as all legislation passed before December 31, 1979; but it specifically excluded all programs of Conservation and Solar (CS) Energy, the Department of Energy. The energy-use projections under the baseline scenario were developed using the ORNL/MITRE pooled computer model system; they are shown in Fig. 1.2. As indicated, the baseline energy use grows to 107 quads in 2000. Be definition, these projections include the effect of higher fuel prices and tax credits legislated prior to December 1980.

A second scenario, the program impact analysis scenario (PIAS), included not only the specifications of the baseline scenario but also all of the sectoral DOE/CS programs that were assessed. It too was

Table 1.1. Summary of baseline scenario macroeconomic and macroenergy specifications

Variable	Average annual growth rate (%)	
	1980-1985	1980-2000
• Economic		
- Real gross national product	3.2	2.8
- Real disposal income	3.0	2.8
- GNP deflator	8.2	6.9
• Demographic		
- Population	0.9	0.8
- Labor force	1.5	1.1
• Uninflated fuel prices		
- Oil products	4.4	2.0
- Electricity	1.1	0.6
(Other inputs: gas and coal prices, detailed industrial production levels, etc.)		

analyzed using the ORNL/MITRE pooled computer model system. The resulting energy-use projections are shown in Fig. 1.3. The differences between the two projections characterize the estimated impacts of analyzed sectoral programs of the DOE/CS organization.

Due to time constraints, the effects of cross-sectoral programs of community systems and energy storage systems were estimated but not integrated in the above scenario analyses. Their energy and oil impacts are therefore separately shown in Fig. 1.1. Because of the overlapping nature of their impacts, while the joint effect of analyzed sectoral and cross-sectoral programs would be larger than the effects of the sectoral programs, the joint effect also would probably be smaller than the sum of the effects of the sectoral and cross-sectoral programs.

Moreover, due to resource constraints, no estimates were developed for the following programs: urban waste, energy extension service, state energy conservation program, emergency energy conservation, energy conversion and utilization, appropriate technology small grants, and energy-related inventions program.

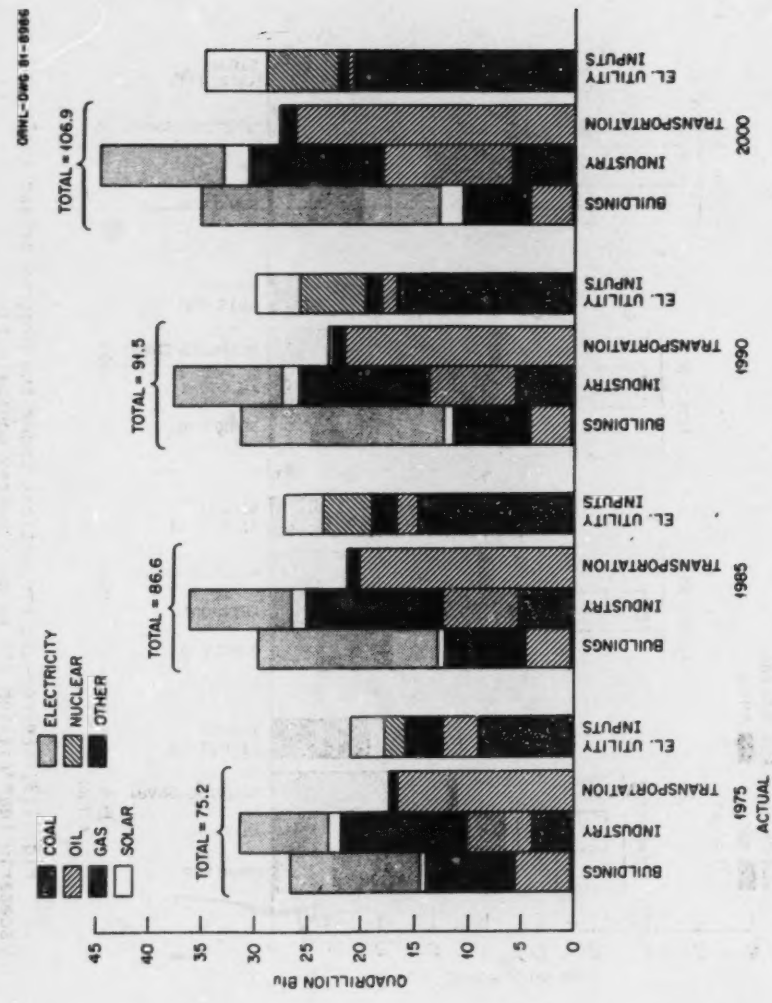

Fig. 1.2. Baseline energy-use projections (quadrillion Btu primary energy equivalent).

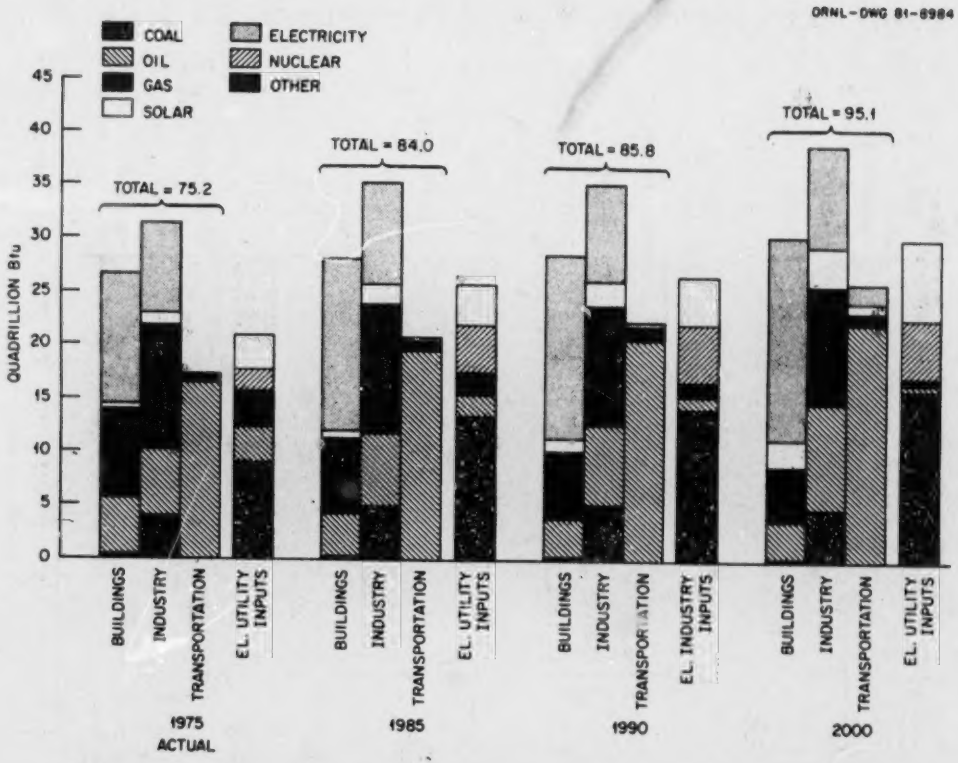

Fig. 1.3. Energy-use projections under the program impact analysis scenario (quadrillion Btu primary energy equivalent).

892

This study establishes that an integrated assessment of conservation and solar programs can be performed. Such an approach represents a major step forward in the methodology for assessment of the DOE/CS program portfolio (or even the entire DOE portfolio) in comparison with the previously used individual program assessments. The details of the new ORNL/MITRE methodology do need to be more fully developed, however. Also, due to time and resource limitations, it was possible to develop only a single set of estimates. Thus it was not possible to explicitly treat the uncertainty in the estimates.

Details of the analysis, further implications of the overall results, and study caveats are presented in Sect. 2. Also, documentation of sectoral details may be found in Sects. 4 through 9. Appendixes contain additional details.

(Figures 1.4 and 1.5 provide numerical information for Figs. 1.2 and 1.3, respectively.)

95-882 O—82——57

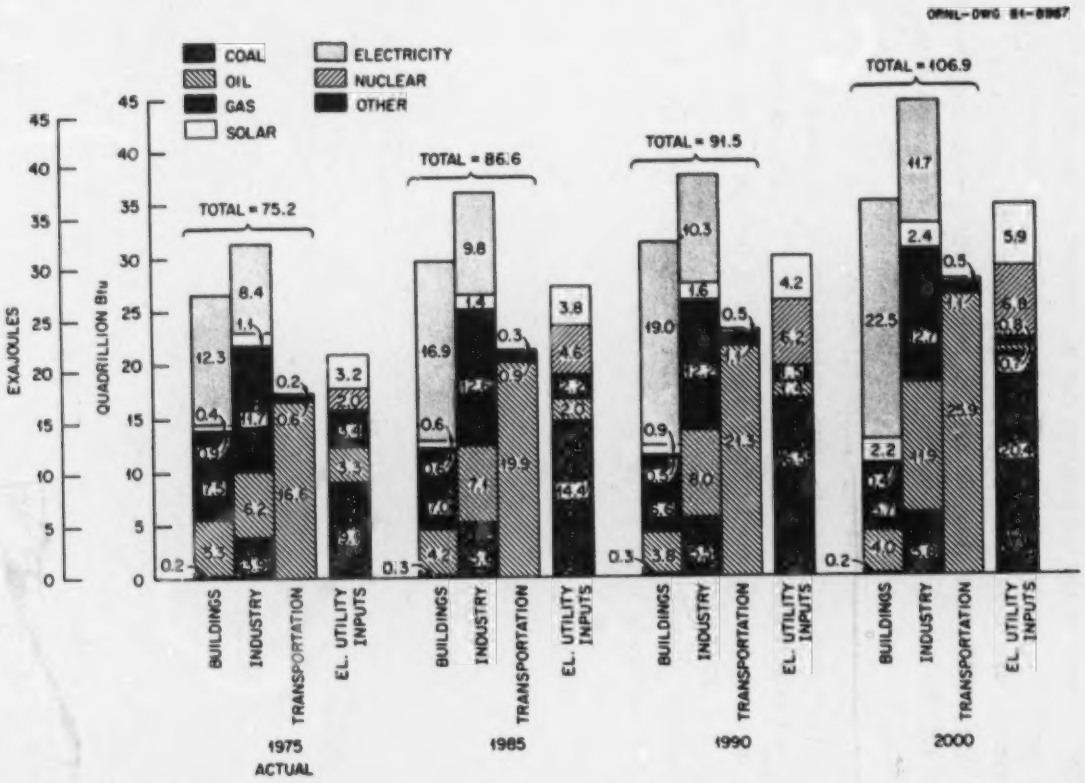

Fig. 1.4. Baseline energy-use projections (1 x 10^{15} Btu primary energy equivalent). (This figure provides numerical information for Fig. 1.2.)

894

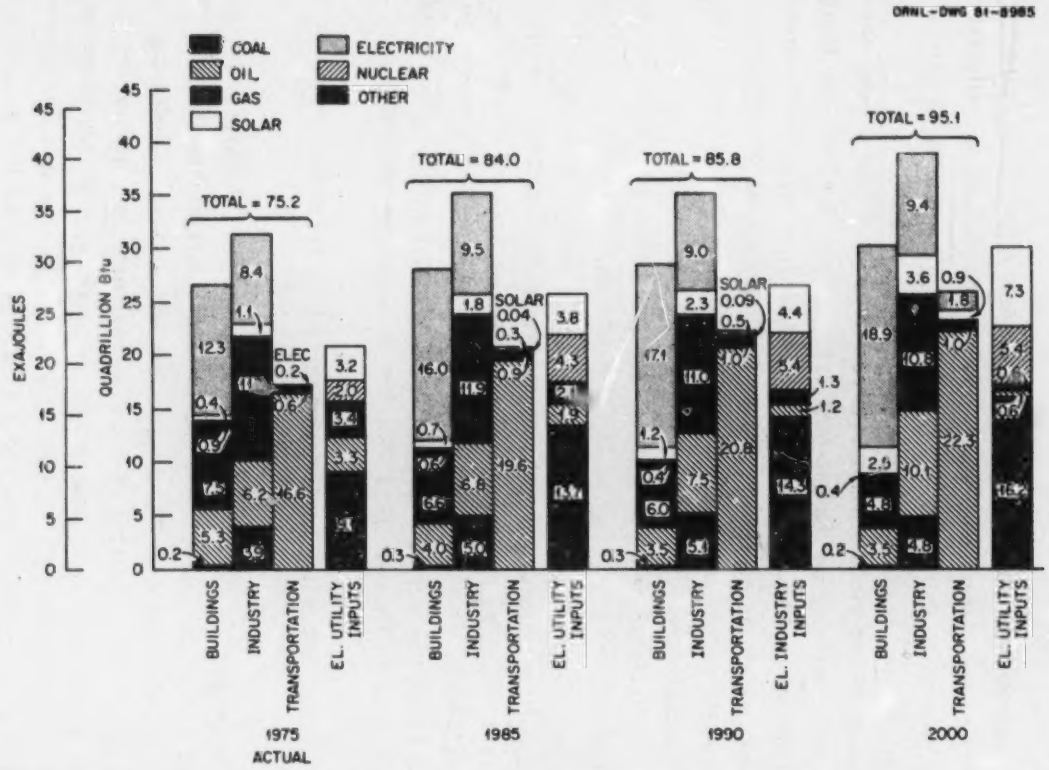

Fig. 1.5. Energy-use projections under the program impact analysis scenario (1 x 10^{15} Btu of primary energy equivalent). (This figure provides numerical information for Fig. 1.3.)

868

2. ANALYSIS OVERVIEW

Shail Parikh, Study Coordinator

2.1 Policy Planning and Evaluation Function of DOE's Office of Conservation and Solar Energy

The DOE Office of Conservation and Solar Energy (OCSE) is responsible for identification, assessment, and implementation of federal conservation and solar programs. This is an important function, since appropriately chosen conservation and solar programs can aid in balancing the U.S. energy supply-demand picture during the period in which the economy shifts from its heavy reliance on conventional oil and gas. For sound national energy planning, choices for conservation and solar alternative programs must be made within an assessment framework that accounts for the most likely economic and energy supply-demand futures, as well as for a range of possible but unpredictable events.

OCSE is assisted by a staff group from the Office of Policy, Planning, and Evaluation (OPPE). In particular, the Strategic Planning and Policy Analysis Division of OPPE is responsible for (1) analyzing conservation and solar policy options, (2) evolving an assessment framework for programmatic pursuit of these options, and (3) developing analyses concerning the attractiveness of current and proposed programs. These efforts have been conducted in conjunction with DOE's annual program planning and budgeting cycle to improve the allocation of budgetary resources.

2.2 ORNL/MITRE Study: Combining Computer Model Analyses with Policy Analyst Judgments

In December 1979 the Strategic Planning and Policy Analysis Division initiated a major effort to unify and improve significantly the OCSE program portfolio assessment process. This effort also included the identification and evaluation of a unified approach for integrating diverse documents such as multiyear programs, program impacts related to budget estimates, legislative initiatives, etc. It called for coordinated participation of representatives of all OCSE program activities and required important contributions of OPPE contractors.

The main responsibility for quantitative analysis was assigned to two laboratories — Oak Ridge National Laboratory and Brookhaven National Laboratory. The Energy Division and the Conservation Program of ORNL were given a lead role; they were to conduct modeling and analysis activities related to estimating energy-saving impacts of existing and new conservation and solar programs. The Energy Division has a broad capability to perform quantitative analysis of future energy demand on a national and/or regional basis. The Conservation Program participates in the development and improvement of the Energy Division's energy demand analysis capability; it also pursues a broad spectrum of technology research projects, such as those related to energy storage systems and end-use technologies. ORNL is expanding its involvement in solar technology. Based on previous efforts, it enlisted the assistance of the MITRE Corporation to aid in producing a comprehensive analysis of conservation and solar options. Thus ORNL undertook a six-month preliminary strategy study of the estimation of energy-saving impacts of current and proposed conservation and solar programs that included the participation of ORNL's and MITRE's computer modelers and policy analysts.

2.3 Key Features of the ORNL/MITRE Study

If this study was to have near-term relevance, its results would have to be used as inputs into DOE's annual Program Planning and Budgeting System (PPBS) cycle. Therefore it was necessary to organize the analytical effort consistent with the short time frame of the PPBS cycle. This consideration forced a tight schedule upon the analysis of the existing and proposed conservation and solar (CS) programs.

All CS energy-saving impact-related programs were considered in the study. However, as the study progressed it was discovered that some project information was not available for analysis. There were also cases for which DOE had funded much more intensive audits of projected and reported near-term energy savings. For these, the study used the DOE-developed information.

Significant interaction occurred between the representatives of the program offices, OPPE staff, and ORNL/MITRE analysts. In some cases, such interaction revealed omissions or incorrect interpretations and resulted in revisions of the estimate.

The ORNL/MITRE approach consisted in estimating energy-saving impacts for all analyzed program elements under a common set of energy prices and economic growth assumptions. A three-step estimation procedure was followed: (1) development of energy consumption projections under the baseline scenario, (2) element-by-element estimation of energy-saving impacts for each program, and (3) development of energy consumption projections under the program impact analysis scenario (PIAS) that incorporate into the baseline analysis the changes due to program effects.

The baseline analysis provides a best estimate of the energy use in the presence of existing legislation, but without the programs. Assumptions concerning key demographic variables (such as population and labor force), macroeconomic variables (such as gross national product and disposable income), and energy variables (such as fuel prices, including the price of imported oil) formed a common set of inputs for the exercise. These data were developed by BNL and Dale Jorgenson Associates (DJA).[1] DOE's fiscal and policy guidelines provided the assumptions concerning oil import prices. Because oil needs to be imported during the study's planning horizon, the imported oil price formed a basis for generating fuel prices for end-use sectors and for different points of end use through application of appropriate markups. Using BNL's TESOM model with these fuel prices, domestic energy production and consumption were projected. Economic growth projections were made using DJA's LITM model. In these computations the characterization of energy use is highly aggregated: it is based on historical data in LITM and on exogenously specified price elasticities in TESOM.

The baseline scenario driving variables were used by the ORNL/MITRE analysts as inputs to the computer models (Table 2.1) for developing sectoral projections of energy use. These pooled models are the following: ORNL model of the residential sector (originally developed by Hirst and Carney[2]), ORNL model of the commercial sector (originally developed by

Table 2.1. ORNL/MITRE Study: computer models used

1.	ORNL model of the residential sector
2.	ORNL model of the commercial sector
3.	Oak Ridge industrial model
4.	ORNL highway gasoline demand model
5.	Faucett TEC model
6.	FAA's models for jet fuel computations
7.	MITRE's SPURR (SHACOB)
8.	MITRE's SPURR (industrial process heat)
9.	MITRE's SPURR (utilities)

Jackson et al.[3]), Oak Ridge industrial model (ORIM) (being developed by Reister et al.[4]), ORNL highway gasoline demand model (being developed by Greene and Rose[5]), Jack Faucett Associates' TEC model[6] (recently transferred to ORNL), Federal Aviation Agency's models for jet fuel computations, and MITRE Corporation's SPURR model[7] with a capability to evaluate penetration of solar and renewable resource technologies in the buildings, industrial, and utilities sectors. The computations employed a "sequential conservation-solar interface." That is, the input assumptions were first used by the ORNL models for developing fuel and end-use projections for the residential, commercial, industrial, and transportation sectors. Next, fuel-use projections of residential, commercial, and industrial sectors, together with the BNL/DJA inputs to the ORNL systems, were used by MITRE's SPURR model for developing solar-use projections.

Once the baseline projections were developed, the exercise followed relatively independent and parallel assessments of energy-saving impacts of the individual program elements. The program elements of the following DOE program groups were analyzed: building and community systems, industrial programs, transportation programs, state and local programs, energy storage systems, solar building systems, solar industrial programs, and solar power systems. The energy-saving impact estimation process was

not uniform across all programs. For some cases such as building and community systems, the estimates depended largely on computer-model-based calculations. For others such as energy storage systems, the estimates depended on off-line analyses.

The third and final step consisted in identifying changes in the baseline projections resulting from program effects. Model adjustments characterizing the program effects were made by the ORNL/MITRE analysts, and the pooled model system operated to analyze the PIAS, consisting of the baseline scenario with modifications to include program effects. The resulting projections eliminate double counting related to intrasectoral programs. This avoids much of the double counting but not all of it. Some double counting related to conservation-solar interaction and cross-sectoral effects in buildings and industry sectors still remains.

In addition to analyzing the current CS programs and developing associated PIAS projections, the ORNL/MITRE team also attempted to examine certain programmatic enhancements. Apparently, the particular enhancement package chosen was not well conceived. The ORNL/MITRE analysis indicated that it was not an effective package. The sector parts of this document, therefore, contain the analysis of two program packages, current programs and enhancements. They include analysis of two corresponding scenarios, PIAS-I (current programs) and PIAS-II (enhancements). This overview does not dwell on PIAS-II projections at all. It concerns itself only with the PIAS-I projections and refers to them as PIAS projections.

2.4 Overview of Baseline Analysis

As noted earlier, the ORNL/MITRE study was implemented after a set of initial conditions, the scenario specifications, were established. There are two key areas of scenario specifications: macroeconomic and energy price variables and existing legislation to be included in the baseline scenario.

The first set of variables is summarized in Table 2.2. Real gross national product is assumed to grow at 3.2% per annum from 1980 to 1985

Table 2.2. Summary of baseline scenario macroeconomic and macroenergy specifications

Variable	Average annual growth rate (%)	
	1980 to 1985	1980 to 2000
Economic		
Real gross national product	3.2	2.8
Real disposable income	3.0	2.8
GNP deflator	8.2	6.9
Demographic		
Population	0.9	0.8
Labor force	1.5	1.1
Uninflated fuel prices		
Oil products	4.4	2.0
Electricity	1.1	0.6
(Other inputs: gas and coal prices, detailed industrial production levels, etc.)		

and at 2.8% per annum over the entire 1980 to 2000 period. The inflation rate, as summarized in the GNP price deflator, is assumed to be 8.2% and 6.9% over the 1980 to 1985 and 1980 to 2000 periods respectively. These key inputs were developed by BNL/DJA on the basis of DOE/PE's policy and fiscal guidelines.

The fuel price assumptions are as follows. Real prices of oil products are assumed to grow at 4.4% per annum over the near-term period 1980 to 1985 and at a lower rate of 2.0% per annum over the entire 1980 to 2000 period. The crude-oil import price in the year 2000 is assumed to be $45/bbl. The real electricity prices are assumed to grow at 1.1% per annum over the 1980 to 1985 period and at 0.6% per annum over the 1980 to 2000 period. For comparison, one may obtain the nominal rates of growth by combining the growth rate of the real prices and the GNP deflator.

The ORNL/MITRE models actually used sector-specific fuel prices developed by BNL/DJA, rather than the composite fuel prices of the preceding paragraph. Furthermore, some models such as ORIM for the

industrial sector and SPURR for solar buildings analysis were operated at regional levels. Individual sectoral modelers developed disaggregations of the national fuel prices to the appropriate regional level. Documentation of this regionalization may be found in the respective sector parts.

The second area of baseline scenario specifications consists of effects of existing legislation without the analyzed CS programs. This seemingly simple premise of the baseline scenario is difficult to specify in actual practice. There are several issues that must be dealt with; first is the cutoff date. Legislation passed after December 31, 1979, was not considered in the specification of the baseline scenario. Thus, for example, in the analysis of active solar systems, the crude-oil windfall profit tax legislation passed in mid-1980 was not included in the baseline. This legislation allows for higher amounts of tax credits on residential renewable resource expenditures, compared with tax credits allowed by legislation in effect on December 31, 1979. Second is the issue of legislatively mandated CS programs, and those requiring substantial budgets and included in the analysis were excluded from the baseline. An example of excluded legislation is PL 94-413, the Electric and Hybrid Vehicle Research Demonstration Act of 1976. In order to provide impact estimates of similar programs in the solar area, however, MITRE Corporation analyzed two baseline scenarios — one that excluded these programs (referred to as baseline scenario in Sect. 7) and the other that included these programs (referred to as legislative scenario in Sect. 7). Yet another example is 1985 corporate average fuel economy standards. Because no substantial CS program is directed at implementation of these standards and because sufficient enforcement effort appeared to ensure success of this legislation, they were included in the baseline.

For details of how existing legislation was incorporated in the baseline scenario specifications in each of the sectors, the reader is referred to the sectoral parts.

Having determined the baseline scenario specifications, the ORNL/MITRE team developed baseline analysis, the primary component of which is development of sectoral energy use and solar displacement projections with the aid of computer models.

Oak Ridge models of residential, commercial, industrial, and transportation sectors are end-use oriented, engineering-economic models. Thus, for example, in the residential sector analysis, the ORNL model employs projections of the housing stock and an endogenous treatment of thermal integrity to determine the demand for space heat. Such a formulation has an advantage in that for programs such as building energy performance standards (BEPS), the model adjustment lever is directly related to the policy variable.

The end-use demands for 1985, 1990, and 2000 projected by Oak Ridge models are given in Table 2.3.

After the end-use projections from the Oak Ridge models were developed, the results for buildings and industry sectors were provided to MITRE analysts to develop solar fuel displacement projections following the "sequential conservation-solar interface" referred to earlier. Although the ORNL/MITRE analysts recognized that this was not the ideal approach, it had been identified as the best one could do with the existing energy models, deadlines, and financial resources.

The buildings sector and the industry sector components of the SPURR model are also end-use oriented and employ explicitly modeled capital-stock adjustment dynamics. Market penetration methodology for these sectors is also based on a meaningful logic, in that the rate and degree of penetration of solar technologies depend upon their relative cost advantage over the conventional technologies. The utility sector component takes uncertainty into account and analyzes the mix of power-plant capacity under assumed capital cost distributions to derive penetrations of solar technologies, using the probability of the least-cost decision rule and market acceptance limits.

The baseline solar projections, including fuel displacements, from the SPURR model are given in Table 2.4.

In order to develop a complete energy consumption summary, it was necessary to identify required data that were not produced by the ORNL/MITRE pooled model system, These data are for asphalt, kerosene, LPG, etc., in buildings; industrial feedstocks; energy use by nonmanufacturing sectors of agriculture, mining, and construction; electricity

Table 2.3. Baseline energy-use projections from Oak Ridge models

(by end use)

	(Quadrillion Btu)			
	1975	1985	1990	2000
Residential				
Space heat	8.06	7.08	7.11	7.29
Air conditioning	1.08	1.21	1.34	1.61
Water heat	2.24	2.53	2.69	2.97
Refrigerators	0.92	1.63	1.69	1.74
Freezers	0.38	0.74	0.78	0.84
Cooking	0.76	0.97	1.03	1.11
Lighting	0.90	0.96	1.00	1.17
Other	1.31	1.49	1.68	1.98
Residential total	15.65	16.62	17.32	18.72
Commercial				
Heat	4.14	4.78	5.05	5.73
Cool	1.98	2.47	2.81	3.60
Water	0.24	0.29	0.32	0.38
Light	2.11	2.46	2.69	3.14
Other	0.67	0.76	0.76	0.85
Commercial total	9.14	10.76	11.63	13.70
Industrial (manufacturing fuel and power)				
Heat	4.29	4.77	4.71	5.04
Steam	4.75	5.10	5.01	5.33
Mechanical drive	6.47	7.57	7.97	7.95
U. electrical services	1.69	1.96	2.02	2.48
Industrial total	17.20	19.40	19.71	20.80
Transportation				
Automobile	9.50	8.68	8.40	9.22
Light truck	1.85	3.17	3.60	4.48
Heavy truck	2.20	3.94	4.47	6.37
Buses	0.12	0.16	0.17	0.20
Air	1.53	2.40	2.76	3.24
Rail	0.58	0.70	0.78	0.96
Marine	0.85	0.80	0.94	1.30
Pipeline	0.72	1.21	1.71	1.74
Transportation total	17.35	21.05	22.82	27.50

Note: All data have been converted to primary energy equivalent. Also, industrial sector analysis does not include feedstock and energy use by agriculture, mining, and construction sectors.

Table 2.4. Baseline solar projections (including fuel displacements)

	(Quadrillion Btu)			
	1975	1985	1990	2000
Buildings – active[a]	0	0.153	0.385	1.260
Buildings – passive[b]	0	0.003	0.027	0.157
Buildings – photovoltaics[b]	0	0	0.004	0.149
Buildings – firewood[c]	0.4	0.4	0.5	0.6
Industry – process heat[a]	0	0.002	0.039	0.565
Industry – biomass[d]	1.10	1.42	1.53	1.81
Utility – Nonhydro[a]	0	0.05	0.38	1.94
Utility – hydro[e]	3.19	3.7	3.8	4.0
Total solar[f]	4.69	5.73	6.67	10.48

[a]Fuel displacements from SPURR.

[b]Exogenous – assumed to displace fuel; passive measurement is incremental over 1975.

[c]Exogenous – baseline level.

[d]Exogenous – baseline level.

[e]Exogenous input by Oak Ridge coordinator.

[f]Does not include use of alcohol fuels in the transportation sector and dispersed wind energy systems.

fuel mix, etc. Notable among these are energy for industrial feedstocks and nonmanufacturing and the electricity fuel mix. Exogenous specifications for these are given in Table 2.5. It should be noted that implicit in the assumed electricity fuel mix is the effect of oil backout efforts of electric utilities. The information in Tables 2.3 to 2.5 and related details yield the energy consumption summary given in Table 2.6.

Thus baseline energy consumption projections specify the reference used by the ORNL/MITRE analysts as the point of departure for analyzing energy-saving impacts of DOE/CS programs. These projections incorporate ORNL/MITRE analysts' best estimate of the effects of the following three determinants of energy consumption:

Table 2.5. Key missing data in ORNL/MITRE sectoral baseline analysis

	(Quadrillion Btu)			
	1975	1985	1990	2000
Energy use[a]				
Industrial feedstocks and nonmanufacturing	10.92	13.21	14.31	19.94
Electricity nonsolar fuel mix[b]				
Coal	0.51	0.62	0.64	0.71
Oil	0.19	0.09	0.05	0.03
Gas	0.19	0.10	0.06	0.03
Nuclear	0.11	0.20	0.24	0.24
Total[c]	1.00	1.00	1.00	1.00

[a]Developed using trend analysis by Oak Ridge coordination (ref. 8).

[b]Based on BNL/DJA analysis (ref. 1).

[c]Totals may not add due to rounding.

1. economic growth: macroeconomic assumptions, namely, gross national product, disposable income, GNP deflator, and factor (labor and capital) prices;

2. energy prices: oil import prices and associated prices of delivered oil, gas, electricity, and coal to end-use sectors;

3. existing legislation: such as Energy Policy and Conservation Act (applicance labeling, corporate average fuel economy standards, etc.), Power Plant and Industrial Fuel Use Act (requiring extensive substitution of coal for oil and gas by industry and utilities, etc.). However, the legislation requiring a significant budgeted DOE/CS program, such as the Electric and Hybrid Vehicle Research Development and Demonstration Act of 1976, is excluded. Also excluded is the legislation passed after December 31, 1979, such as the Crude Oil Windfall Profit Tax of 1980. Both classes of exclusions conform to the design of the ORNL/MITRE experiment.

Table 2.6. Energy consumption summary under baseline scenario
(quadrillion Btu of primary energy equivalent)

	Coal	Oil	Gas	Other	Nuclear	Solar	Electricity	Total
Year 1975								
Buildings	0.24	5.26	7.52	0.90		0.40	12.30	26.62
Industry	3.86	6.24	11.68			1.10	8.40	31.28
Transportation	0	16.58	0.59			0	0.18	17.35
Electric util.	9.06	3.33	3.35	___	1.96	3.19	-20.88	0
1975 total	13.16	31.41	23.14	0.90	1.96	4.69	0	75.24
Year 1985								
Buildings	0.30	4.18	6.96	0.60		0.56	16.90	29.50
Industry	5.14	7.07	12.63			1.42	9.80	36.06
Transportation	0	19.86	0.85			0	0.33	21.04
Electric util.	14.43	2.03	2.24	___	4.58	3.75	-27.03	0
1985 total	19.87	33.14	22.68	0.60	4.58	5.73	0	86.60
Year 1990								
Buildings	0.30	3.84	6.60	0.49		0.92	18.99	31.14
Industry	5.49	8.03	12.17			1.57	10.29	37.54
Transportation	0	21.27	1.05			0	0.49	22.81
Electric util.	16.49	1.40	1.51	___	6.19	4.18	-29.77	0
1990 total	22.27	34.53	21.33	0.49	6.19	6.67	0	91.49
Year 2000								
Buildings	0.20	3.99	5.71	0.43		2.17	22.46	34.95
Industry	5.80	11.91	12.66			2.38	11.72	44.46
Transportation	0	25.93	1.09			0	0.48	27.50
Electric util.	20.42	0.74	0.78	___	6.77	5.94	-34.65	0
2000 total	26.43	42.57	20.23	0.43	6.77	10.48	0	106.92

Note: totals may not add due to rounding.

2.5 Program Impact Assessments

2.5.1 Scope of ORNL/MITRE assessments

The baseline analysis described earlier is intended to provide the best estimate of the energy use in the presence of existing legislation, but without any CS programs. Having developed baseline analysis, the ORNL/MITRE analysts continued the exercise by evaluating the program elements of various program offices of DOE/CS. The general procedure used in these evaluations is as follows. Each program element was first analyzed independently. The analysis started from the statement of the physical activities as provided in the program element description prepared in conjunction with DOE's PPBS cycle. For all analyzed program elements, the energy saving and displacing and oil saving impacts were estimated. For some of them such as energy storage systems, the capital saving impacts were also assessed; but the analysis stopped there. The ORNL/MITRE analysts did not attempt to assess other impacts, such as redistribution effects, emergency preparedness effects, etc. Neither did they attempt to explore the relationships between the program element budget levels and the physical activities. This approach is consistent with the assignment to ORNL of assessing energy-saving impacts of DOE/CS's programs. However, it is evidently far short of performing complete *cost-benefit* assessments for *each* of the program elements.

The next step after completion of independent program element assessments was to eliminate, to the extent feasible, the double counting of energy saving and displacing and oil saving impacts of program elements. To this end, the ORNL/MITRE analysts sought to specify groupings of program elements the aggregate assessment of which would minimize double counting. It was found that suitable groupings could be formed by pooling all program elements for an end-use sector. Such groupings are logical from the energy accounting standpoint as well as from the DOE/CS organizational standpoint. As shown in Fig. 2.1, the DOE/CS organization in conservation and solar areas is consistent with the end-use sector accounting framework. Furthermore, it was felt that in the buildings and industry sectors, the conservation and solar

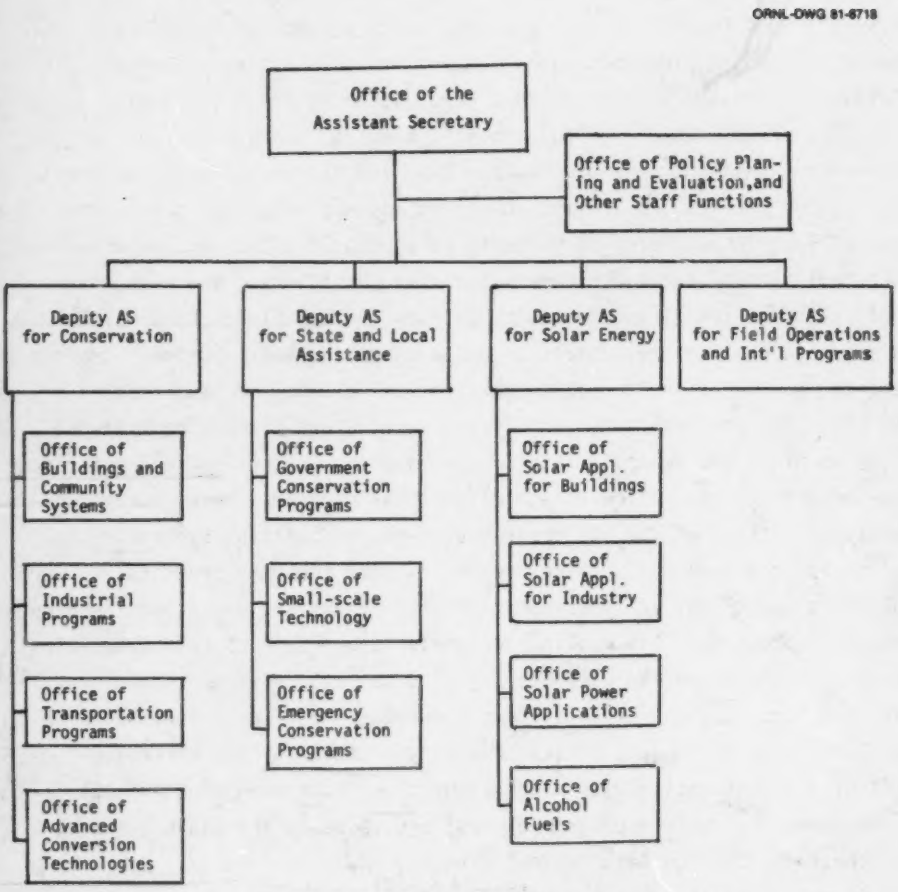
ORNL-DWG 81-6718
Office of the Assistant Secretary
Office of Policy Planing and Evaluation, and Other Staff Functions
Deputy AS for Conservation
Deputy AS for State and Local Assistance
Deputy AS for Solar Energy
Deputy AS for Field Operations and Int'l Programs
Office of Buildings and Community Systems
Office of Industrial Programs
Office of Transportation Programs
Office of Advanced Conversion Technologies
Office of Government Conservation Programs
Office of Small-scale Technology
Office of Emergency Conservation Programs
Office of Solar Appl. for Buildings
Office of Solar Appl. for Industry
Office of Solar Power Applications
Office of Alcohol Fuels

Fig. 2.1. Organization of conservation and solar energy, U.S. Department of Energy (as of March 17, 1980).

95-882 O—82——58

programs should be grouped separately for the same reasons (time and resource limitations) that dictated the sequential conservation-solar interface in the baseline analysis. Thus the most appropriate grouping was specified to be all program elements under control of an office director. Thus, for example, joint impacts of all program elements of Office of Transportation Programs were estimated after the estimation of the impacts of vehicle propulsion R&D, electric and hybrid vehicle R&D, transportation system utilization R&D, and alternate fuels utilization. There were cases, however, where it was not possible to estimate joint effects for all program elements of a program office due to unique characteristics of certain elements and time constaints. One such case is Office of Buildings and Community Systems (BCS). First, ORNL/MITRE analysts did not analyze impacts of urban waste and small-business program elements because of their unique characteristics that set them apart from other BCS program elements. Second, energy and oil saving effects of the hospital and school grants program and the weatherization assistance program, both of the office of state and local programs, were considered jointly with those of the BCS program elements of building systems, residential conservation service, technology and consumer products, applicance standards, analysis and technology transfer, and federal energy management program. This pooling for analysis was felt to be appropriate because all these program elements are directed at individual buildings. Third and last, the community systems program element was not pooled with the above grouping because of its community orientation and resulting difficulty of estimating within the study time frame the joint effects of the community systems program element and those in the above grouping with the individual building orientation.

As noted earlier, the purpose of assessing joint impacts of program elements was to eliminate double counting of energy saving and displacing and oil saving impacts of program elements. Those within a particular CS program office appeared to provide a suitable first-level aggregation. However, within the scope and time limitations of the ORNL/MITRE study, it was not feasible to carry this aggregation out to one or two higher levels, that is, estimation of joint impacts of all program elements under

control of a deputy assistant secretary or the entire CS organization under control of the assistant secretary.

2.5.2 Impacts of individual program elements

The energy-saving impact estimation process for individual program elements was not uniform across all programs. In some cases, such as buildings and community systems, the estimates depended largely on computer-model-based calculations. For others, such as energy storage systems, the estimates depended on off-line analyses. In all situations, however, the modeler-analyst had to be sufficiently experienced with the individual projects to exercise judgment about the plausible and justifiable levels of market potential and market penetration under stated levels of programmatic efforts.

It should be emphasized that although the baseline analysis of the ORNL/MITRE study involved extensive use of computer models of energy use and solar penetration analysis, when it came to assessing impacts of program elements, the computer models often served as convenient accounting tools that took care of those chores not requiring human judgments. This model contribution relieved the ORNL/MITRE analysts from such cumbersome chores and permitted them to expend more effort on better understanding of the program elements and on careful assessment of the penetration assumptions consistent with effectiveness of the program elements. Details of the penetration assumptions of ORNL/MITRE analysts are provided by them in the individual sections.

This approach of using computer models to develop baseline analysis and judgements to assess penetration effects of DOE/CS programs is an important strength of the ORNL/MITRE study. It constitutes a significant step in DOE/CS-wide program assessment across the board (the approach is expandable to DOE-wide assessments) on the basis of an internally consistent frame of reference. It also highlights an important application, with a definite competitive advantage over other methods, of the computer models in the public policy process.

Yet another important aspect of the ORNL/MITRE study was the significant interaction of ORNL/MITRE analysts and representatives from energy-conservation-related program offices. This interaction permitted different views of the program impacts to enter the estimation process. There were several instances where original estimates of ORNL/MITRE analysts were significantly different from those of the program offices. Sometimes the differences were due to omissions on the part of the ORNL/MITRE analysts; their inclusion usually caused upward revision of the estimates. Where it was not possible to include the omissions and revise the estimates, the omissions were clearly identified and noted. In some cases it was clear that the high program office estimates represented goals that, in the judgement of ORNL/MITRE analysts, could not be achieved. In such cases the analysts' estimates were reported and the reason for the differences noted. The overall effect of this approach has been that for many programs it was possible to produce a single set of ORNL/MITRE estimates and to have them accepted as being reasonable by the program office representatives.

Table 2.7 shows the program element coverage by the ORNL/MITRE study; two aspects are shown. A check (✓) in column 1 indicates whether a program element was analyzed. A check (✓) in column 2 indicates where the estimation process was significantly aided by the computer models. Table 2.8 provides energy saving and displacing and oil saving impacts of the analyzed program elements.

2.5.3 Joint impacts of program element groupings

The individual program elements impact assessment provides ORNL/MITRE analysts' best estimate of incremental energy saving and displacement effects of a particular program element with reference to the baseline energy-use projections and in the absence of the rest of the analyzed program elements. In reality, however, all program elements are operating simultaneously. One would not expect their collective effect to equal an arithmetic sum of the individual effects. For example, one would expect the joint effect of BEPS and analysis and technology transfer to be smaller than the sum of the individual effects.

Table 2.7. Program element coverage

Program element	Coverage	Program impacts estimated using computer models
1. Buildings and community systems		
Building systems	✓	✓
Residential conservation service	✓	✓
Community systems	✓	
Urban waste		
Small business		
Technology and consumer products	✓	✓
Appliance standards	✓	✓
Analysis and technology transfer	✓	✓
Federal energy management program	✓	✓
Total	✓	✓
2. Industrial		
Waste energy reduction	✓	
Process efficiency	✓	
Implementation and deployment		
Cogeneration	✓	
Total	✓	✓
3. Transportation		
Vehicle propulsion R&D	✓	
Electric and hybrid vehicle R&D	✓	
Transportation system utilization	✓	
Alternate fuels utilization	✓	
Total	✓	✓
4. State and local		
Hospital and school grants	✓	✓
Weatherization assistance	✓	✓
Energy management partnership act	✓	
Total		
5. Energy impact assistance		
6. Multisector		
Appropriate technology		
Invention program		
Energy conversion technology		
Total		

Table 2.7 (continued)

Program element	Coverage	Program impacts estimated using computer models
7. Energy storage systems		
Battery storage	✓	
Thermal and mechanical storage	✓	
Total	✓	
8. Solar building systems		
Active solar heating and cooling	✓	✓
Passive solar heating and cooling	✓	
Photovoltaics	✓	
Total	✓	
9. Solar industrial applications		
Solar thermal energy systems	✓	✓
Biomass energy systems		
Total		
10. Solar power applications		
Ocean systems	✓	✓
Wind systems	✓	✓
Total	✓	
11. Alcohol fuels		
Alcohol market analysis		
Alcohol market development		
Alcohol systems development		
Total		

Table 2.8. Energy impacts of individual program elements
(quadrillion Btu of primary energy equivalent)

	Energy savings and displacements				Oil savings			
	1985	1990	2000	1980–2000	1985	1990	2000	1980–2000
Buildings and community systems								
Building systems	0.59	1.32	2.72	32.7	0.06	0.12	0.24	3.5
Residential conservation service	0.17	0.19	0.18	3.8	0.05	0.05	0.06	1.1
Community systems	0.10	0.21	1.00	7.0		0.04	0.24	1.6
Technology and consumer products	0.10	0.08	0.11	1.4	0.02	0.01	0.01	0.1
Appliance standards	0.20	0.60	1.16	18.4	0.01	0.02	0.04	0.6
Analysis and technology transfer	0.17	0.75	1.83	24.2	0.02	0.05	0.13	1.8
Federal energy management program	0.07	0.08	0.09	1.7	0.01	0.01	0	0.1
Industrial								
Waste energy reduction	0.4	1.0	2.1	20.0	0.05	0.17	0.5	4.0
Process efficiency	0.4	1.1	3.0	26.0	0.07	0.14	0.7	4.9
Cogeneration	0.05	0.20	0.50	4.4	0.01	0.04	0.1	0.9
Transportation								
Vehicle propulsion R&D	0.001	0.04	0.95	4.0	0.001	0.04	0.95	4.0
Electric and hybrid vehicle R&D	0	0	0	0[a]	0	0.02	1.09	3.9
Transportation system utilization	0.12	0.31	0.76	6.9	0.12	0.31	0.76	6.9
Alternate fuels utilization	0	0	0	0[a]	0.04	0.15	1.65	7.7
State and local								
Hospital and school grants	0.11	0.08	0.04	1.9	0.02	0.01	0.01	0.3
Weatherization assistance	0.03	0.03	0.03	0.6	0.005	0.005	0.005	0.1

Table 2.8 (continued)

	Energy savings and displacements				Oil savings			
	1985	1990	2000	1980–2000	1985	1990	2000	1980–2000
Energy storage systems								
Battery storage	-0.002	-0.002	-0.051	-0.2	[b]	[b]	[b]	1.0
Thermal and mechanical storage	0.001	0.004	0.41	1.3	0.006	0.105	0.486	2.9
Solar building systems								
Active solar	0.12	0.21	0.24	3.1	0.03	0.05	0.06	0.8
Passive solar	0.003	0.012	0.028	0.3	0.001	0.003	0.007	0.1
Photovoltaics (including electric utilities)	0	0.011	0.28	1.6	0	0.003	0.02	0.1
Solar industrial applications								
Solar thermal energy systems (including electric utilities)	0.003	0.17	1.23	6.2	0.001	0.02	0.13	0.7
Solar power applications								
Ocean systems	0	0	0.06	0.3	0	0	0.002	0.01
Wind systems (including dispersed)	0.02	0.13	0.23	1.7	0.002	0.01	0.02	0.1

[a]Possibly negative.

[b]Not available.

In order to remove this double counting to the maximum extent feasible, the ORNL/MITRE analysts continued the exercise by evaluating the energy saving and displacement impacts of certain groupings of program elements. These groupings are specified in Table 2.9; the rationale for their selection has already been discussed in Sect. 2.5.1. In order to develop the aggregate impact assessments, the ORNL/MITRE analysts started with the baseline energy-use projections and superimposed the program impacts on them. This superimposition required consideration of each end use (e.g., space heat) separately and operation of the appropriate model with model adjustments corresponding to all program elements in a grouping. Thus, for example, the end-use projections for the buildings sector were developed by operating Oak Ridge models of the residential and commercial sector with model adjustments corresponding to all eight program elements specified under the buildings-conservation column in Table 2.9. It may be appropriate for the reader to recall that these model adjustments for each program element were developed judgmentally and through interaction of ORNL/MITRE analysts and representatives from energy conservation program offices. The resulting model runs produced energy-use projections of end uses in residential and commercial sectors that reflected the baseline scenario specifications of economic growth, energy prices, and existing legislation, as well as the DOE/CS programs in the grouping titled "buildings — conservation." Similar computations were performed for the industrial and transportation sectors. The resulting energy-use projections are given in Table 2.10. The solar-use projections for groupings "buildings — solar" and "electric utilities — solar" were developed assuming additivity of program impacts. The resulting solar-use projections are given in Table 2.11. It should be noted that Table 2.11 also contains "buildings — firewood" and "utility — hydro," the levels of which correspond to baseline projections of Table 2.4, and "industry — biomass," the level of which is based on incremental fuel displacements believed to be feasible and not on an estimate of the programmatic effect or a goal.

The complete energy consumption summary development followed a procedure similar to the one for baseline analysis. Key missing data

Table 2.9. Aggregation map for program element groupings

Program element analyzed \ Program element grouping	Buildings – conservation	Buildings – community systems	Buildings – solar	Industry – conservation	Industry – solar thermal	Transportation	El. utilities – solar	Energy storage systems
Buildings and community systems								
Building systems	✓							
Residential conservation service	✓							
Community systems		✓						
Technology and consumer products	✓							
Appliance standards	✓							
Analysis and technology transfer	✓							
Federal energy management program	✓							
Industrial								
Waste energy reduction				✓				
Process efficiency				✓				
Cogeneration				✓				
Transportation								
Vehicle propulsion R&D						✓		
Electric and hybrid vehicle R&D						✓		
Transportation system utilization						✓		
Alternate fuels utilization						✓		
State and local								
Hospital and school grants	✓							
Weatherization assistance	✓							
Energy storage systems								
Battery storage								✓
Thermal and mechanical storage								✓
Solar building systems								
Active solar			✓					
Passive solar			✓					
Photovoltaics			✓					
Solar industrial applications								
Solar thermal energy systems					✓			
Solar power applications								
Ocean systems							✓	
Wind systems							✓	

Table 2.10. PIAS energy-use projections from Oak Ridge models (by end use)

	(Quadrillion (Btu)		
	1985	1990	2000
Residential			
Space heat	6.55	6.24	6.03
Air conditioning	1.14	1.16	1.27
Water heat	2.49	2.52	2.61
Refrigerators	1.61	1.56	1.47
Freezers	0.73	0.73	0.72
Cooking	0.97	1.02	1.08
Lighting	0.96	1.00	1.17
Other	1.44	1.58	1.81
Residential total	15.88	15.81	16.16
Commercial			
Heat	4.27	4.39	4.63
Cool	2.39	2.60	3.15
Water	0.27	0.29	0.34
Light	2.42	2.56	2.75
Other	0.74	0.72	0.76
Commercial total	10.09	10.56	11.63
Industrial (Manufacturing — fuel and power)			
Heat	4.60	4.09	3.68
Steam	4.80	4.50	3.90
Mechanical drive	7.11	6.67	6.18
U. electrical services	1.95	1.95	1.63
Industrial (MFP) total	18.46	17.21	15.39
Transportation			
Automobile	8.65	8.34	8.72
Light truck	3.16	3.58	4.30
Heavy truck	3.89	4.34	5.88
Buses	0.16	0.17	0.19
Air	2.36	2.62	3.03
Rail	0.70	0.78	0.91
Marine	0.80	0.93	1.29
Pipeline	1.21	1.71	1.69
Transportation total	20.93	22.46	26.01

(Note: For accounting conventions, see note under Table 2.3.)

Table 2.11. PIAS solar projections (including fuel displacements)

	(Quadrillion Btu)		
	1985	1990	2000
Buildings — active[a]	0.268	0.591	1.498
Buildings — passive[a]	0.006	0.039	0.185
Building — photovoltaics[a]	0	0.015	0.217
Buildings — firewood[b]	0.4	0.5	0.6
Industry — process heat[a]	0.005	0.086	0.870
Industry — biomass[c]	1.81	2.23	2.73
Utility — nonhydro[a]	0.07	0.62	3.33
Utility — hydro[b]	3.7	3.8	4.0
Total solar[d]	6.26	7.88	13.43

[a]Fuel displaced.

[b]These are baseline levels from Table 2.4.

[c]Incorporates incremental fuel displacements believed to be feasible. Industrial biomass programmatic effect not estimated.

[d]Does not include use of alcohol fuels in the transportation sector and dispersed wind energy systems.

of Table 2.5 were used without modification; the results are summarized in Table 2.12.

Comparison of Tables 2.6 and 2.12 permits one to specify aggregate conservation and solar program effects in different sectors (Table 2.13) as well as fuel savings and solar-use increments (Table 2.14).

Disaggregation of oil savings in Table 2.14 into conservation and solar programmatic effects is of interest. This disaggregation is shown in Table 2.15. It is performed as follows. Savings due to conservation are from the Oak Ridge Model outputs. Oil savings due to solar programs in buildings, industry, and utilities are obtained using exogenous fractions applied to incremental solar fuel displacements (from Tables 2.4 and 2.11). In the transportation sector, the solar-related oil savings are from Oak Ridge model outputs and equal the alcohol fuel amounts in

Table 2.12. Energy consumption summary under program impact analysis scenario
(quadrillion Btu of primary energy equivalent)

	Coal	Oil	Gas	Other	Nuclear	Solar	Electricity	Total
Year 1985								
Buildings	0.30	3.98	6.59	0.57		0.67	15.99	28.10
Industry	5.01	6.83	11.90			1.81	9.47	35.03
Transportation	0	19.61	0.85			0.04	0.33	20.83
Electric util.	13.65	1.92	2.12		4.33	3.77	-25.79	0
1985 total	18.96	32.34	21.46	0.57	4.33	6.30	0	83.96
Year 1990								
Buildings	0.30	3.54	6.01	0.43		1.15	17.11	28.53
Industry	5.12	7.46	10.98			2.32	8.98	34.86
Transportation	0	20.80	1.04			0.09	0.53	22.46
Electric util.	14.31	1.21	1.31		5.37	4.42	-26.62	0
1990 total	19.72	33.00	19.35	0.43	5.37	7.97	0	85.84
Year 2000								
Buildings	0.20	3.51	4.83	0.37		2.50	18.88	30.29
Industry	4.84	10.12	10.80			3.60	9.44	38.81
Transportation	0	22.30	1.04			0.87	1.80	26.01
Electric util.	16.21	0.59	0.62		5.38	7.33	-30.12	0
2000 total	21.25	36.53	17.28	0.37	5.38	14.30	0	95.11

Note: totals may not add due to rounding.

921

Table 2.13. Estimated aggregate sectoral conservation and solar effects of analyzed program elements

(quadrillion Btu of primary energy equivalent)

	1985			1990			2000		
	Baseline	PIAS	Change	Baseline	PIAS	Change	Baseline	PIAS	Change
Conservation effect									
End-use sectoral fuel consumption									
Buildings	29.50	28.10	-1.40	31.14	28.53	-2.61	34.95	30.29	-4.66
Industry	36.06	35.03	-1.03	37.54	34.86	-2.68	44.46	38.81	-5.65
Transport	21.04	20.83	-0.21	22.81	22.46	-0.35	27.50	26.01	-1.49
Total	86.60	83.96	-2.64	91.49	85.84	-5.65	106.92	95.11	-11.81
Solar effect									
Solar use									
Buildings	0.56	0.67	0.11	0.92	1.15	0.23	2.17	2.50	0.33
Industry	1.42	1.81	0.39	1.57	2.32	0.75	2.38	3.60	1.22
Transport	0	0.04	0.04	0	0.09	0.09	0	0.87	0.87
Electric utilities	3.75	3.77	0.02	4.18	4.42	0.24	5.94	7.33	1.39
Total	5.73	6.30	0.57	6.67	7.97	1.30	10.48	14.30	3.82

Note: Totals may not add due to rounding.

922

Table 2.14. Estimated aggregate fuel savings and solar use increments due to analyzed programs

	1985			1990			2000		
	Baseline	PIAS	Change	Baseline	PIAS	Change	Baseline	PIAS	Change
Coal	19.87	18.96	-0.91	22.27	19.72	-2.55	26.43	21.25	-5.18
Oil	33.14	32.34	-0.80	34.53	33.00	-1.53	42.57	36.53	-6.04
Gas	22.68	21.46	-1.22	21.33	19.35	-1.98	20.23	17.28	-2.95
Other	0.60	0.57	-0.03	0.49	0.43	-0.06	0.43	0.37	-0.06
Nuclear	4.58	4.33	-0.25	6.19	5.37	-0.82	6.77	5.38	-1.39
Solar	5.73	6.30	+0.57	6.67	7.97	+1.30	10.48	14.30	+3.82
Total	86.60	83.96	-2.64	91.49	85.84	-5.65	106.92	95.11	-11.81

Note: totals may not add due to rounding.

Table 2.15. Disaggregation of oil savings into conservation and solar effects

	(Quadrillion Btu)		
	Conservation	Solar	Total
1985			
Buildings	0.17	0.03	0.20
Industry	0.1	0.14[b]	0.24
Transportation	0.21	0.04	0.25
El. utilities	0.11[c]	0[illegible]	0.11
1985 Total	0.59	0.21	0.80
1990			
Buildings	0.25	0.05	0.30
Industry	0.30	0.27[b]	0.57
Transportation[a]	0.38	0.09	0.47
El. utilities	0.18[c]	0.02	0.19
1990 Total	1.11	0.42	1.53
2000			
Buildings	0.40	0.08	0.48
Industry	1.30	0.48[b]	1.79
Transportation[a]	2.76	0.87	3.63
El. utilities	0.11[c]	0.05	0.15
2000 Total	4.57	1.47	6.04

[a]Transportation sector analysis also considered availability and use of coal and oil shale liquids. These amounts are not disaggregated from oil in our presentation. Such a disaggregation would show lower oil use in the PIAS case, contributing additional oil savings in the amounts of 0.06 quad in 1990 and 0.78 quad in 2000.

[b]Includes 0.14 quad in 1985, 0.25 quad in 1990, and 0.36 quad in 2000 of incremental biomass believed to be feasible. Industrial biomass programmatic effect not estimated.

[c]Indirect oil savings due to electricity conservation in the end-use sector. They do not include effects of oil backout efforts by electric utilities.

(Note: Totals may not add due to rounding.)

energy consumption summaries (Tables 2.6 and 2.12). The oil savings for electric utilities in the conservation column arise indirectly from electricity conservation in the end-use sectors. Finally, the total savings equal the sum of those from conservation and solar effects and could also be derived from energy consumption summaries of Tables 2.6 and 2.12.

The energy and oil impacts of all groupings of program elements can now be specified; they are given in Table 2.16.

The above aggregation of energy-saving impacts to sectoral-level program element groupings is an important first step. It captures much of the double counting but not all of it. The cross-sectoral double counting and conservation-solar interaction-related double counting in buildings and industry sectors still remain. Thus the energy impact of community systems and of energy storage systems is not included in the above presentation. Also, full economic equilibrium of energy conservation, active and passive solar systems, and biomass is not achieved in buildings and industry sectors. Notwithstanding these deficiencies, the above analysis does convey some important insights. These are discussed in the next section.

2.6 Analysis of Results

2.6.1 Overall implications of ORNL/MITRE estimates

The first set of observations summarized in Table 2.17 concerns the time profiles of aggregate energy impacts. The ORNL/MITRE estimate is that the effect of analyzed sectoral conservation programs is to reduce primary energy consumption by 2.6 quads in 1985, 5.7 quads in 1990, and 11.8 quads in 2000; and the effect of solar programs is to enhance solar use by 0.6 quad in 1985, 1.3 quads in 1990, and 3.8 quads in 2000. Together, these programs are estimated to reduce the fossil and nuclear use by 3.2 quads in 1985, 7.0 quads in 1990, and 15.6 quads in 2000.

The oil savings grow from 0.8 quad in 1985 to 6.0 quads in 2000. The combined oil and gas savings are even more significant, growing

95-882 O—82——59

Table 2.16. Summary of energy and oil impacts of DOE/CS's sectoral and cross-sectoral program groupings

(quadrillion Btu of primary energy equivalent)

	Energy savings and displacements			Oil savings		
	1985	1990	2000	1985	1990	2000
Buildings — conservation[a]	1.4	2.6	4.7	0.2	0.3	0.4
Buildings — solar[a,e]	0.1	0.2	0.3	0.03	0.05	0.08
Industry — conservation[a,f]	1.0	2.7	5.7	0.1	0.3	1.3
Industry — solar thermal[a,e]	[g]	0.05	0.3	[g]	0.02	0.1
Transportation — conservation[a]	0.2	0.4	1.5	0.3	0.5	3.6
Transportation — alc. fuels[a]	0.04	0.09	0.87			
El. utilities — solar[a,e]	0.02	0.2	1.4	[g]	0.02	0.05
El. utilities — indirect[a,c]				0.1	0.2	0.1
Buildings — comm. systems[b]	0.1	0.2	1.0	[g]	0.04	0.2
Energy storage systems[b]	[g]	[g]	0.4	0.01	0.1	0.5
Industry — biomass[d]	0.4	0.7	0.9	0.1	0.3	0.4

[a]These aggregates are derived through PIAS projections.

[b]These cross-sectoral aggregates are based on independent program impacts alone.

[c]Oil savings are due to electricity conservation in end-use sectors.

[d]Incremental displacements believed to be feasible. Industrial biomass programmatic effect was not estimated.

[e]There is a solar accounting convention difference between Table 2.8 and this table as follows. In Table 2.8, impacts of electric utility photovoltaics are included in solar building systems, and impacts of electric utility solar thermal (+repowering) applications are included in industrial solar thermal applications. Here, both sets of impacts are included in electric utilities — solar.

[f]Energy savings include indirect natural-gas T&D loss reduction due to gas savings in all sectors.

[g]Less than 0.005.

Table 2.17. Time profiles of aggregate energy impacts (quadrillion Btu of primary energy equivalent)

	1985	1990	2000
Reduction in primary energy consumption	2.6	5.7	11.8
Solar-use enhancement	0.6	1.3	3.8
Reduction in fossil and nuclear use	3.2	7.0	15.6
Oil savings	0.8	1.5	6.0
Oil and gas savings	2.0	3.5	9.0
Energy savings due to cross-sectoral programs	0.1	0.2	1.4
Oil savings due to cross-sectoral programs		0.1	0.7

from 2.0 quads in 1985 to 9.0 quads in 2000. Since in many applications oil and gas are easy substitutes, the latter statistic is probably more appropriate in assessing the oil import reduction impact of analyzed programs. *If* one assumes that all oil and gas savings reduce oil imports, then the implication of the ORNL/MITRE estimate is that analyzed sectoral conservation and solar programs will reduce oil imports by 1.0 MMB/D in 1985, 1.8 MMB/D in 1990, and 4.5 MMB/D in 2000.*

The effects of cross-sectoral programs of community systems and energy storage systems are significant but not integrated with the rest of the ORNL/MITRE analysis. In the year 2000, they are estimated to produce 1.4 quads of energy savings and 0.7 quad of oil savings. If it were possible to eliminate the double counting between sectoral and cross-sectoral program impacts by performing a full economic equilibrium computation, the resulting amounts would be somewhat smaller.

The second set of observations concerns sectoral impacts — in terms of fossil plus nuclear use and solar use. These are summarized in Table 2.18 and are derived directly from Tables 2.6 and 2.12. Several

*Assumed conversion factor, 1 MMB/D = 2 quads/y.

Table 2.18. Sectoral impacts on fossil plus nuclear use, electricity use, and solar use of analyzed sectoral programs

(quadrillion Btu of primary energy equivalent)

	Fossil + nuclear	Electricity	Solar	Total change
Year 1985				
Buildings	-0.60	-0.91	+0.11	-1.40
Industry	-1.10	-0.33	+0.39	-1.03
Transportation	-0.25	0	+0.04	-0.21
Direct sectoral use	-1.95	-1.24	+0.54	-2.64
El. utilities	-1.26	+1.24	+0.02	0
Total primary energy consumption	-3.21	0	+0.57	-2.64
Year 1990				
Buildings	-0.95	-1.88	+0.23	-2.61
Industry	-2.13	-1.31	+0.75	-2.68
Transportation	-0.48	+0.04	+0.09	-0.35
Direct sectoral use	-3.56	-3.15	+1.07	-5.65
El. utilities	-3.39	+3.15	+0.24	0
Total primary energy consumption	-6.94	0	+1.30	-5.65
Year 2000				
Buildings	-1.42	-3.58	+0.33	-4.66
Industry	-4.61	-2.28	+1.22	-5.65
Transportation	-3.68	+1.32	+0.87	-1.49
Direct sectoral use	-9.71	-4.53	+2.42	-11.81
El. utilities	-5.91	+4.53	+1.39	0
Total primary energy consumption	-15.62	0	+3.82	-11.81

Note: All numbers refer to changes from baseline. Also, totals may not add due to rounding.

explanatory remarks in the organization of this table are in order. Three components of sectoral impacts are given here — fossil and nuclear use, electricity use, and solar use. The nuclear portion of fossil and nuclear use is applicable only for electric utilities. Thus, the fossil plus nuclear use column provides change in fossil fuel use for end-use sectors. Fossil and nuclear use is combined for electric utilities because this study assumed an exogenous fossil-nuclear mix and has no significant disaggregate conclusion. Next, the direct sectoral use row provides information on the change in end-use consumption of fossil fuels, electicity and solar energy resulting from analyzed sectoral programs. The electric utilities row disaggregates the electricity use reduction in end-use sectors to reduction in fossil and nuclear inputs and an increase in electricity generation from solar energy. The implied changes in the primary energy use, because of electricity use reduction from the electric utilities row, are combined with those from the direct sectoral energy use row and reported in the total primary energy consumption row.

Several observations concerning the sectoral energy impacts are of interest. As shown, the largest sectoral fossil fuel reduction (and including nuclear in electric utilities) occurs in the electric utility sector, accounting for 38% of the total reduction in 2000. Based on an exogenous coal-nuclear mix (Table 2.5), the bulk of this reduction is in coal use — growing from 0.8 quad in 1985 to 4.2 quads in 2000 (from Tables 2.6 and 2.12).

Second, the transportation sector row must be interpreted with care. The estimated fossil fuel-use reduction in this sector comes from three effects — energy conservation, increased solar use, and *increased* electricity use. Thus, in the year 2000, the reduction of 3.7 quads in fossil fuel use is attributed to 1.5 quads of energy conservation, 0.9 quad of solar-use enhancement (alcohol fuels), and 1.3 quads of fossil fuel displacement from increased use of electric cars. Of course, since electricity must somehow be produced, the 1.3 quads of electricity required for electric cars will necessitate the offsetting fossil, nuclear, and solar inputs in the electric utilities sector. Also, the oil share

in fossil fuels used by the transportation sector is far larger than the oil share in electric utility inputs. For these reasons, the increased electricity use in the transportation sector does not necessarily reduce the fossil fuel use but causes interfuel substitutions in the desired direction, namely, toward reduction in oil use.

Third, the solar-use enhancement in the buildings sector is estimated to be quite small: 0.1 quad in 1985, 0.2 quad in 1990, and 0.3 quad in 2000. The ORNL/MITRE accounting convention includes active, passive, and photovoltaic systems for buildings, but only the amounts causing fuel displacements. In spite of the total solar use in buildings of 0.7 quad in 1985, 1.2 quads in 1990, and 2.5 quads in 2000 (Table 2.12), this small estimated enhancement from solar buildings programs is because of the assessment by ORNL/MITRE analysts that the existing legislation calling for large tax credits for solar installations on buildings will achieve a large portion of the projected solar use, leaving a smaller room for programmatic enhancement. Further investigation is recommended of this assessment.

Table 2.19 summarizes sectoral impacts in terms of oil savings and oil and gas savings. The transportation sector dominates the oil-saving picture. But when oil *and gas* savings are considered together, the importance of the buildings and industry sectors becomes clearer. On the other hand, because the baseline oil and gas use by electric utilities is projected to decline, the impact of sectoral programs on electricity conservation-induced indirect oil (and gas) savings in electric utilities is estimated to be much smaller in relation to the direct oil and gas savings in the end-use sectors.

Finally, it is of interest to consider the value of oil savings and oil and gas savings (Table 2.20). Using the oil and gas savings of Table 2.17 as the point of departure, the discounted present values are derived for three real discount rates: 3, 8, and 10%. These calculations show that at a 3% real discount rate, oil savings are worth over $200 billion and oil and gas savings are worth over $370 billion. Cross-sectoral programs, if independently evaluated, would add about 10% to the dollar value of oil savings. Complete cost-benefit assessment was beyond the scope of the ORNL/MITRE study. For example, the private

Table 2.19. Oil and gas saving impacts of analyzed sectoral programs

(quadrillion Btu of primary energy equivalent)

	1985	1990	2000
Oil savings			
Buildings	0.2	0.3	0.5
Industry	0.2	0.6	1.8
Transportation	0.3	0.5	3.6
Utilities	0.1	0.2	0.2
Total	0.8	1.5	6.0
Oil and gas savings			
Buildings	0.6	0.9	1.4
Industry	1.0	1.8	3.7
Transportation	0.3	0.5	3.7
Utilities	0.2	0.4	0.3
Total	2.0	3.5	9.0

Note: Impacts of cross-sectoral programs of community systems and energy storage systems are not included. See Table 2.17 for a summary of these impacts. Also, totals may not add due to rounding.

costs must be assessed to determine net benefits. It is clear, however, that the dollar values of oil and gas savings are very large.

Yet another aspect of the public benefits of oil savings is the incremental social value resulting from reduction in the vulnerability-related premium on imported oil. For example, assuming a $10/bbl premium reduction, the present value of oil savings at a 3% real discount rate is $50 billion.

2.7 Study Caveats

The ORNL/MITRE study is an important milestone in coordinated and detailed quantitative analysis of federal energy programs in the conservation and solar area. The need for this work arose due to the fact that only about a year ago, all conservation and solar programs were brought under control of a single assistant secretary. Therefore the institutional pressures to perform this type of integrated analysis are relatively recent. This study takes a large step in the direction of achieving

Table 2.20. Present value of oil savings and oil and gas savings from analyzed DOE/CS's sectoral programs

	1980-1985	1985	1985-1990	1990	1990-2000	2000	Total
Present value of oil savings							
Oil savings[a] (quads)		0.8		1.5		6.0	
Oil savings over the period[b] (quads)	2.0		5.7		37.5		45.2
Value at $40/bbl (billion dollars)	13.3		38.0		250.0		
Present value discounted[c] at real rate of (billion dollars)							
3%	12.4		30.4		160.5		203.3
8%	11.0		21.3		78.8		111.1
10%	10.5		18.6		59.8		88.9
Present value of oil and gas savings							
Oil and gas savings[a] (quads)		2.0		3.5		9.0	
Oil and gas savings over the period[b] (quads)	5.0		13.8		62.5		81.3
Value at $6.67/mmBtu[d] (billion dollars)	33.4		92.0		416.9		
Present value discounted[c] at real rate of (billion dollars)							
3%	31.0		73.7		267.6		372.3
8%	27.6		51.7		131.4		210.7
10%	26.3		45.0		99.8		171.1

[a] From Table 2.19.

[b] Assume linear growth in oil savings over a period.

[c] Discounting assumes value-lumping at midperiod.

[d] Assume 1 bbl = 6 million Btu.

consistency in analysis by different parts of the DOE/CS organization and in development of portfolio analysis and related decision-making information through interaction of modelers and analysts, DOE/CS planning staff, and program office representatives.

In order to produce a timely analysis, it was not feasible for the ORNL/MITRE team to develop new analytical capabilities. Existing capabilities were employed. The calculations were performed by experienced analysts of ORNL and MITRE organizations. They used computer models that possessed most of the needed accounting detail but were not developed expressly for the purpose of program impact assessments.

The result is that a set of estimates has been produced using state-of-the-art capabilities. Judgments have been used extensively in developing them. Care has been taken to document the analysis and results. The estimates can serve as a benchmark against which future estimates from more thorough studies can be compared. Thus a process can be evolved to maintain a current set of estimates incorporating new information as it becomes available.

The caveats enumerated here should be viewed in this light. Our intent is to indicate areas where new work is needed to help improve the credibility of and the confidence in the similar analyses to be produced in the future as well as to make the analysis more comprehensive in terms of the impact areas.

The impact of uncertainty in the baseline scenario has not been studied here. A look at Table 2.2 makes it clear that the growth rates for key variables, including the two very fundamental ones for energy analysis, the real gross national product, and the price of oil products, are subject to considerable uncertainty. For example, the CONAES demand panel[9] assumed the GNP growth rate of 2% per year over the 1975 to 2010 period, and the EIA's 1978 annual administrator's report[10] assumed a GNP growth rate of 3.3% per year over the 1977 to 1995 period in its mid-mid scenario projections. The ORNL/MITRE baseline scenario specified a 2.8% per year growth rate over the 1980 to 2000 period. A different growth rate would imply a different size and mix of energy, utilizing capital stock as well as a different standard of living, and therefore a different

level of baseline energy consumption. There is perhaps even more uncertainty in the price of oil products. The ORNL/MITRE study was given the specification of 45 1980$/bbl for the imported oil price in the year 2000. This price was based on DOE/PE's policy and fiscal guidance; higher fuel prices now seem likely. They have two opposing effects. Price-induced conservation cuts into the conservation potential, leaving less room for program-induced conservation. But each Btu of conservation is more valuable. Similar arguments hold for solar. From the analytical viewpoint, there is no easy way to tackle these uncertainties. Monte Carlo simulation-type approaches would be too expensive to implement. One pragmatic approach is to try several carefully designed alternate baseline scenarios and study the sensitivity of program impacts in a coordinated exercise similar to this study.

State-of-the-art model-based market penetration prediction methods are weak, including those used in the ORNL/MITRE pooled model system. The weakness is due to the fact that they involve a key judgmental component affecting the penetration. Actually, the market penetration algorithms of ORNL/MITRE models are quite sophisticated. They are based on logical arguments. The technology-oriented engineering-economic models of the residential and commercial sectors developed at ORNL employ energy efficiency vs initial cost trade-off curves to determine life-cycle cost minimizing choices. They account for market imperfections through a logic that selects options with somewhat higher life-cycle costs but ensures that the degree of imperfection will decline as the fuel prices rise. Also, technology options are relatively easy to incorporate in these models. The main judgmental input required is in specification of the market imperfection function. Since these models have been widely used, their logic is better understood by the users, and therefore their limitations, too, are better understood. On the other hand, the SPURR model components are relatively new and not as widely used. Their market penetration calculations, however, are also based on logical arguments. For example, the SPURR buildings component[11] determines market penetration on the basis of the life-cycle cost ratio of conventional vs solar systems. SERI is in the process of developing a data base[12] that capitalizes on

this market penetration logic. The weakness, however, arises in the need for judgmental selection of a particular market penetration curve to be used. Similarly, the SPURR utility component uses the market penetration logic of cost distributions for different types of power-plant hardware, and the penetration is based on the probability of least-cost and market acceptance limits. This plausible logic is not unique to SPURR. The probability of a least-cost decision rule is also used in the ISTUM model.[13] The problem is not in this logic but, once again, in identification of a particular set of cost distributions and time profiles of market acceptance limits, both of which require judgmental specifications. The ORNL/MITRE approach has been to use informed judgment and documentation of the key assumptions of technology cost characteristics and penetration curves.

Treatment of costs is weak. This study considred the physical activities of analyzed programs and assessed their energy impacts. It did not consider at all the relationship between the underlying budgets and given physical activities. There are overlapping programs in DOE/CS. For example, the electric vehicles program appears in both transportation and energy storage program packages. Such overlaps may increase the cost effectiveness through complementary differences in programmatic thrusts or decrease it due to avoidable duplication. This part of the analysis was considered to be beyond the scope of the ORNL/MITRE study. Obviously, it must be included in any complete cost-benefit assessment. A second problem is the difficulty of estimating private costs. An example is the incremental private cost in new-car purchases necessary to bring about program-induced fuel efficiency improvements.

The program element impact estimates by themselves may not be acceptable for use in the PPBS process. Estimates are developed and presented at several levels of aggregations. The higher the level of aggregation, the smaller the probable error. A corollary is that for individual program elements, the estimates may have a large error. It is for this reason that the estimates must be used with care. On the one hand, a program element could be viewed as the appropriate level of detail and a homogeneous item to analyze in order to arrive at reasonable

aggregate estimates of CS program groupings required for overall analysis. On the other hand, the detailed element-by-element estimates developed by ORNL/MITRE analysts may not be acceptable by themselves for the detailed element-by-element budget allocation decisions that are made during the PPBS cycle. PPBS is a complex process involving defensible analysis as well as many discussions within the DOE/CS organization. The element-by-element estimates developed in conjunction with this study could serve as a point of departure. This is one way in which this work could feed into the PPBS process. However, there are large uncertainties in the element-by-element energy-saving estimates. For example, the impact estimates of technology RD&D programs depend heavily upon the market penetration assumptions. Sensitivity of impacts to market penetration assumptions needs to be studied and results analyzed. There are similar uncertainty-related issues for other types of programs. Thus it is apparent that enhanced and detailed analysis needs to be developed by the respective program element managers in conjunction with the PPBS process.

The electricity consumption projections are lower than those found in other studies such as EIA's 1978 annual administrator's report.[10] The main difference is that in ORNL/MITRE projections, the electricity fraction is relatively constant over time under both scenarios. Electrification, if implemented as a policy to reduce oil consumption, can further reduce vulnerability of the U.S. to oil import supply disruption. This area of investigation was not pursued in any detail in the ORNL/MITRE study.

Only the energy-saving impacts of DOE/CS programs are analyzed in this study. As noted earlier, the ORNL/MITRE analysts did not attempt to assess other impacts, such as redistribution effects, oil import vulnerability reduction effects, emergency preparedness effects, etc. Neither did they attempt to explore relationships between the program element budget levels and the physical activities. This approach is consistent with the scope of the ORNL/MITRE study. However, it is evidently far short of performing a complete cost-benefit assessment of each of the program elements.

The ORNL/MITRE study did not analyze effects beyond the 1980 to 2000 period. It also did not assess the contribution of federal programs in facilitating a smoother transition away from use of natural oil. It is generally accepted that the shift away from inefficient energy use and relatively large oil and gas consumption to efficient energy use and renewable energy resource use must be achieved over time. High oil prices will provide the prime instrument for this transition. Federal programs will make selective contributions to speed and facilitate the transition. Providing adequate reasonable-cost energy supplies for future generations is difficult to justify through cost-benefit assessments using relatively high discount rates (such as 10% real). Also, an increase in the number of viable alternatives to oil and gas would facilitate a smoother transition to an economy that is not heavily dependent on oil and gas. The analytical methods are primitive, and the supporting arguments are not well developed. Hence they cannot provide anything that comes close to a complete evaluation of these benefits. The ORNL/MITRE analysts did not attempt to quantitatively address these aspects.

Finally, a large portion of the solar-use enhancement in the industrial sector is the *incremental industrial biomass use* believed to be feasible, which, as noted earlier, is not actually an estimate of the programmatic effect (see Tables 2.11 and 2.16). Because industrial biomass is a significant component of incremental solar use resulting from solar industrial programs, we chose to include these effects in our presentation of energy impacts of analyzed sectoral programs (Tables 2.13 through 2.19).

In addition to the above caveats, two issues related to accounting for solar contributions are noteworthy.

Accounting of wind, photovoltaics, and solar thermal electric (plus repowering) is not uniformly treated in this study. Impacts of dispersed wind at building sites are included in electric utilities (Tables 2.8 and 2.16). For reporting of energy-saving impacts of program elements, those of electric utility photovoltaics are included in the

program element solar buildings — photovoltaics, and those of solar thermal electric (plus repowering) are included in industrial solar thermal (Table 2.8). Clearly, any future analysis must clear up these accounting irregularities in a satisfactory way.

Passive use of solar is treated as a source of energy supply. Since there is already a lot of passive solar use in the baseline that cannot be properly measured, the study arbitrarily set the passive solar-use level in the baseline at zero and reported the passive solar-use amount in the PIAS projection as an increment over baseline. An alternate method is to treat passive solar as conservation.

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TABLE 7b

MULTI-SECTOR CONSERVATION

ENERGY-RELATED INVENTIONS PROGRAM

CURRENT PROGRAM OBJECTIVES AND BUDGET

GOALS/OBJECTIVES	ALTERNATIVE METHODS	ANTICIPATED NEEDS	BUDGET JUSTIFICATION AND SERVICES PROVIDED
			Budget FY 1982 $5.4M
• To evaluate the technical merits of all submitted energy-related inventions.	None	Develop incentives before any significant levels of support can occur in the private sector.	Provides: • Evaluation of all submitted energy-related inventions, at the rate of 3000/yr.
• To provide assistance for the R&D of energy-related inventions by individuals and small businesses.			• Grant support for 42 recommended inventions.
• To encourage inventors and innovation through information dissemination.			• Encourage invention and innovation through information dissemination, principally through the media of conferences and workshops.
• To conduct a cost effective system of technical and progress monitoring of funded inventions.			• Monitoring of all funded inventions at 6-month intervals, and assessment and feedback of results to program planning.

AN ASSESSMENT OF THE FEDERAL ROLE IN INDUSTRIAL ENERGY PRODUCTIVITY

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Abstract

There is a continuing debate on the proper role of the Federal Government in assisting industry to achieve more efficient use of energy. The Administration asserts that the National Recovery Tax Act provides the necessary incentives to improve industrial productivity. Many congressional leaders feel that a more participating role such as cost-shared contracts, as currently practiced by DOE, are necessary and essential functions if energy productivity is to be significantly improved. This paper quantitatively examines this issue and establishes the strength of these (and one other) Federal options to motivate industry to improve energy productivity through:]) an increased use of "best available" technology; and 2) developing new high risk technology. The following conclusions are drawn:

]. *The incentives offered by the Economic Recovery Tax Act will provide industry with some incentive to increase the rate at which best available technology is introduced. The increased rate ranges between 3 and 20 percent depending on the discount rate.*

2. *The interest rate is a far more important factor than the Tax Act itself in determining the rate at which best available technology is introduced.*

3. *In the absence of direct Federal cost sharing in RD&D projects there are no incentives enacted or contemplated which would significantly accelerate RD&D in high risk new technology to improve energy productivity.*

4. *The cost effectiveness to the Federal government of cost shared RD&D is extremely high, averaging a 30% return per year on all monies invested after discounting for risk.*

5. *The Federal government's unique ability to tax a corporation's increased profits occasioned by increased energy productivity, makes it the only party involved that can reap such benefits.*

6. *The objectives regarding new technology development, mandated by Congress in the Non-nuclear Act of]974 will not be met unless an active, participating Federal role is continued.*

INTRODUCTION

There can be no argument with the premise that it is in the national interest to improve the efficiency with which energy is consumed in our industry. The perception that increasing energy use efficiency is equivalent to increasing energy supply and in most cases is a faster and less costly avenue of pursuit, is as accurate today as it was when Congress passed the Non-Nuclear Energy Act in 1974. What is at issue is how much improvement in efficiency do we want, how soon do we want to achieve this level of improvement, and what are the most cost effective alternatives to accomplish these goals?

Three levels of industrial energy productivity should be considered; the current level of energy consumption per unit of product (UOP), the energy consumption per UOP using "best available technology," and the potential energy consumption per UOP using "advanced unproven technology." Using 1972 as a base year, it has been estimated that the industrial sector could save up to 22% of their energy consumption through the use of available retrofit technology; 23-28% through the total replacement of plant and equipment with the best available technology and up to 40-50% through the development and installation of new innovative technologies. These are the targets to be weighed in considering the proper Federal role.

In 1974 the Congress, under the Ford Administration, passed P.L. 93-577, Federal Non-Nuclear Energy Research and Development Act, which required the Energy Research and Development Agency (now DOE) to "...Formulate and carry out a comprehensive non-nuclear energy research, development and

demonstration program." "...By initiating..programs..utilizing facilities, capabilities, expertise and experience of...industrial entities..which are appropriate..". This and later legislation (P.L. 94-163 Energy Policy and Conservation Act; P.L. 95-91 Department of Energy Organization Act; P.L. 96-294 Energy Security Act) firmly established the intent of Congress to achieve a level of industrial productivity approaching the 40 to 50% improvement possible through the use of advanced but high risk technology through direct Federal assistance.

The Reagan Administration has challenged this role. As expressed in the National Energy Policy Plan (ref. 1) "Motivated by rising energy prices, individuals, businesses, and other institutions are undertaking serious efforts to modify energy-use patterns of the recent past." The passage of the Energy Recovery Tax Act with its more rapid depreciation, investment tax credits, and research tax credits, coupled with rising energy prices are perceived by this administration to provide all of the motivation required to improve industrial energy productivity.

The analysis presented herein provides insight into the validity of these opposing positions, by examining the strength of the motivating force to induce industry to invest in both "best available" technology, and high risk new technology development.

Background

It is inaccurate to assume that all industry will react in the same way to Federal policy and tax legislation. The industrial sector consists of 20 major two-digit Standard Industrial Classification (SIC) codes and some 400,000 individual corporations. Each individual corporation has economic criteria by which it judges the relative merit of alternative opportunities for capital investment and for advanced technology development expenditures. For every corporation, there are three primary inputs which determine the cost of production: labor, capital, and materials (which include energy and feedstock). As the price of any of these goes up, one or more of the others will be substituted. For example, with increasing labor costs, there has been a significant movement toward the capital investment in automation and robotics (in this case, a substitution of capital for labor). Likewise, it can be anticipated that as the cost of energy increases, industry will in general respond by substituting capital for energy.

The role of energy in a corporation's production costs varies widely among different industries and is primarily associated with the energy intensity of the specific industry. An indication of the importance of energy costs to production costs was presented in the September 14, 1981 issue of Energy Users News (Ref. 2) and is summarized in Table 1 (Cement is not included but probably falls in the Glass, Brick category). Although the energy intensive industries (i.e., those above the industry average line) are especially sensitive to increasing energy costs, clearly, any industry of low profit margin (clothing, leather, etc.) is concerned about erosion of that margin through unnecessary production (energy) costs.

Table 1.

Energy Expenditures as a Percent of Pretax Profits

	1966	1976
Primary Metals	59.0%	217.6%
Glass, Brick	76.6	113.5
Paper	45.1	82.5
Textiles	31.0	70.1
Rubber, Plastics	24.5	69.1
Chemicals	27.4	62.6
Food	21.2	30.4
INDUSTRY AVERAGE	19.1	37.6
Furniture	14.0	27.07
Wood Products	29.4	26.6
Metal Products	14.2	25.1
Elec., Electronics	9.7	21.9
Clothing	12.5	17.3
Petroleum, Coal	11.8	16.7
Miscellaneous	21.9	15.2
Non-electric Machinery	8.2	14.7
Motor Vehicles	7.2	14.3
Leather	12.4	14.2
Instruments	3.9	11.9
Publications	7.2	10.6
Cigarettes	2.1	4.0

What factors influence a corporation to invest capital to decrease energy costs (increase energy productivity)? Although the answer to this question is very complex, three major parameters can be cited:

(1) The energy intensity -- as shown in Table 1, the steel, aluminum, copper, cement, glass, brick, paper, textile, rubber, plastic, chemical and food industries should have strong incentive to invest capital to decrease energy consumption (if this were the only factor involved).

(2) The capital intensity -- The required capital investment for production, is also a critical factor in evaluating willingness to make a discretionary energy conservation investment. The higher the capital intensity, in general, the less likely that money will be available for major discretionary investments. Unfortunately, those industries that are energy intensive are also capital intensive, which reduces their ability to invest in energy conservation per se.

(3) The availability and cost of capital -- capital for investment may be obtained from several sources; the sinking fund for replacement of depreciating property is generally the lowest cost source of capital; second is a portion of the profits not distributed to the stockholders; third is long-term bond issuance; and finally, borrowing at prime rate (or more).

Each corporation has a calculated composite discount rate (rd), which combines the ratio of capital obtained from each source. This discount rate is dependent on the corporation's current debt/equity ratio (often restricted in by-laws) in relation to other corporations in the same industry. Thus it is difficult to obtain quantitative information regarding r_d for any industry. Probably the best estimate for a composite r_d can be obtained by the current long-term bond yield and cost. Several composite values for energy intensive industries for January 1981 (Before Tax Act) and September 1981 (After Tax Act) are shown in Table 2.

Every corporation in the United States must expend capital each year just to stay in business. These expenditures are either non-discretionary or discretionary investments. Non-discretionary investments are those required to enable continued operation of the plant. As such they permit the return on the sunk capital in the plant to continue, but they do not usually improve the productivity of the process stream. Thus they do not provide a net increase in return on investment. Several examples of a non-discretionary investment include:

- Pollution control and safety equipment -- government regulations require that corporations comply with the mandates of EPA and OSHA legislation. The equivalent rate of return (ROR) on such equipment is usually negative since the equipment does not contribute to production but still requires operating and maintenance expense.

TABLE 2. COMPOSITE VALUE OF YIELDS ON LONG-TERM DEBENTURES FOR SELECTED INDUSTRIES

Industry	January 1981 Yield	Sept/Oct 1981 Yield	Implied Increase in r_d
Steel	13.45	15.08	1.63
Textiles	9.93	11.67	1.74
Rubber	14.51	16.75	2.25
Chemicals	13.02	15.25	2.23
Paper	10.23	13.04	2.81
Aluminum	11.53	4.05	2.52
		Implied average increase in r_d	2.20

Source: Wall Street Journal

Yield calculated for each bond issue in group based on interest on current price plus ballon payment at maturity. However, yield for each industry based on multiple bond issues in group.

- o Replacement of worn or failed parts — (e.g., new rolls in a rolling mill) the ROR on such equipment is essentially zero, since the entire process stream could not continue to operate unless replacement is accomplished, but its replacement does not involve an increase in production efficiency.

- o Replacement of entire major process equipment (e.g., new boiler). Often a corporation, in replacing a large piece of equipment, can achieve a positive ROR since the new equipment is often more efficient than the old.

Discretionary capital expenditures are those over which corporate management can exercise judgemental decision. All such expenditures must have a positive ROR if management is properly exercising its mandate. Examples include:

- o Proven process improvement technologies -- (e.g., continuous caster in steel; flying shuttle in weaving textiles, recuperator on forge furnace, condensate return on boiler, etc.). Such expenditures are not required to continue production but increase the efficiency of production such that operating costs are decreased. It is expenditures of this type that permit a corporation to advance from "current technology" towards "best available" technology. It is important to note that no risk of failure is involved in such expenditures.

- New Product Development and Introduction (e.g., Biogenetic introduction of Interferon, microchips, bubble memory, etc.). In this case, the corporation has expended research and development money to prove the viability of production and then makes the decision to invest capital in production machinery. The motivation is the perceived expansion of product lines and increase in market share. Risk is involved in such a decision since the acceptability of the new product in the marketplace is questionable.

- New Process Development and Introduction -- discretionary investment in a new unproven process step designed primarily to improve production efficiency is the least likely type of investment to be made. There are several reasons for this statement:

  - The risk is high. Myers and Sweezy in documenting "Why Innovations Fail" (Ref. 3) state that technologies that have not been proven in pilot or full-scale demonstration have a 65 percent chance of failure (failure being defined as not achieving economic or technical viability).

  - The plant manager is very reluctant to interpose unproven equipment in a process stream if failure could mean loss of production.

- The ability of a corporation to protect its proprietary position in process improvements is severely limited. Competitors learning of the general approach can usually reproduce such improvements (with modification) without violating patent or secrecy provisions. Thus there is little advantage to the developing corporation in terms of improved market share, and only short-term advantage in terms of improved productivity. Generally the attitude of "It's not bad to be second or third" prevails in the manufacturing process industry.

A corporation planning a capital investment plan for the year must balance the non-discretionary investments with the discretionary investments such that the overall rate of return (ROR) equals the corporation's discount rate (r_d). This is shown in the following simplified example:

A corporation has decided to invest $1,000 in capital equipment. Its discount rate is 15 percent. Non-discretionary investments required to stay in business total $400 — they yield no net increase in ROR. The remaining $600 investment capital must yield an increased return of 25 percent or $150 to allow the total return to equal the discount rate on the total $1,000 capital pool. The 25 percent ROR required on discretionary investment is often called the "hurdle rate." Any candidate project whose projected ROR equals or exceeds this hurdle rate is an eligible candidate for investment funds.

A corporation will normally develop a list of those candidate discretionary projects (i.e., in order of decreasing anticipated ROR) and establish a cut-off when the cumulative cost equals the available discretionary funds (i.e., $600 in the example presented).

When non-discretionary investment requirements are high the hurdle rate for discretionary ROR increases significantly.

As interest rates increase, r_d for any given corporation, increases: likewise the hurdle rate must increase. Thus an investment yielding a 25 percent ROR six months ago when the r_d was 15 percent would not be a viable investment today if r_d had risen to 18 percent. Accordingly, the difference (ROR-r_d) is a key parameter in evaluating alternative Federal incentives for motivating investments to improve energy efficiency.

THE IMPACT OF THE ECONOMIC RECOVERY TAX ACT ON INDUSTRIAL INVESTMENT IN BEST AVAILABLE TECHNOLOGY

With this background in mind it is possible to evaluate the strength of the ERTA in motivating industry to invest in proven (low risk) best available technology.

The equation and calculations shown in Table 3 were used to evaluate the ROR parametrically as a function of the discount rate, and the net dollar return on the investment for investments made prior to the passage

Table 3

Calculation of Equivalent rate of Return (ROR) for Energy Related Capital Investments

The equation

$$ROR = e^{\frac{\ln \frac{Y}{C(1-b)}}{n}} - 1$$

is used in calculating ROR where:

$$Y = \sum_{i=0}^{i=n-1} \left\{C_e(1+r_e)^i (1+r_d)^{n-1-i} (1-T)\right\} + \sum_{i=0}^{i=m-1} \left\{\frac{C}{M} (T(1+r_d)^{n-1-i}\right\}$$

ROR = The equivalent rate of return on the investment as if the dollars returned were invested at the discount rate compounded annually over the life of the equipment.

C = the capital required for the investment.

C_e = The annual net dollar return on the investment.

r_e = The average rate at which the cost of energy is anticipated to increase per year over the life of the investment (fraction).

r_d = The discount rate for the corporation (fraction)

n = The useful life of the investment (years).

T = The tax rate of the corporation (faction).

b = Investment tax credit (fraction).

m = The allowable depreciation period (years) (assumes straight line depreciation).

NOTE: ROR differs from the more conventional internal rate of return (IRR) in that the latter assumes the income is invested at the same rate as yielded by this investment analyzed. ROR provides a more meaningful, figure of merit for each individual investment opportunity, since it assumes the income is invested at r_d (the discount rate).

of the Economic Recovery Tax Act and after passage of this act. The results are shown in Figures 1 and 2. In all cases the following inputs were held constant:

C = Capital invested = $1,000

n = Useful life = 15 years

r_e = rate of energy cost increase per year = 0.1

T = corporate tax rate = .46

b = investment tax credit

m = depreciation life allowable

96-862 O—82——61

Standard Inputs

C = $1000
n = 15 yrs.
r_e = .1
T^e = .5
m = 15
b = .1

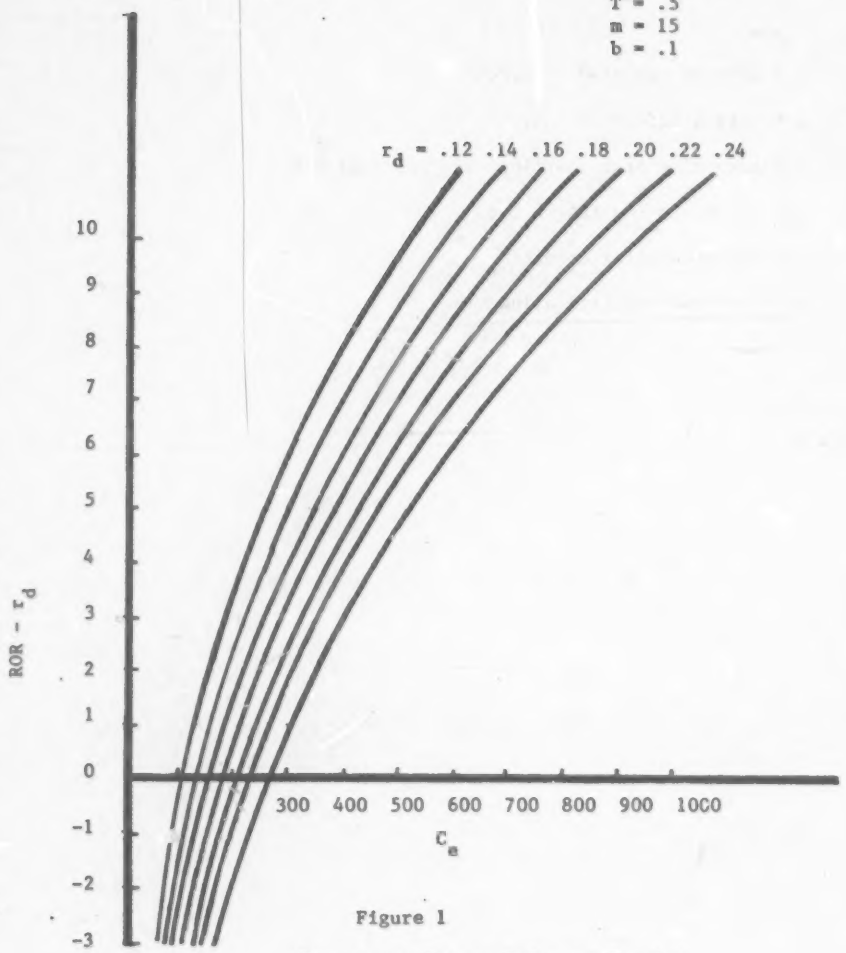

Figure 1

Investment Return Prior to Tax Act

Standard Inputs

C = $1000
n = 15 yrs.
r_e = .1
T^e = .5
m = 5
b = .2

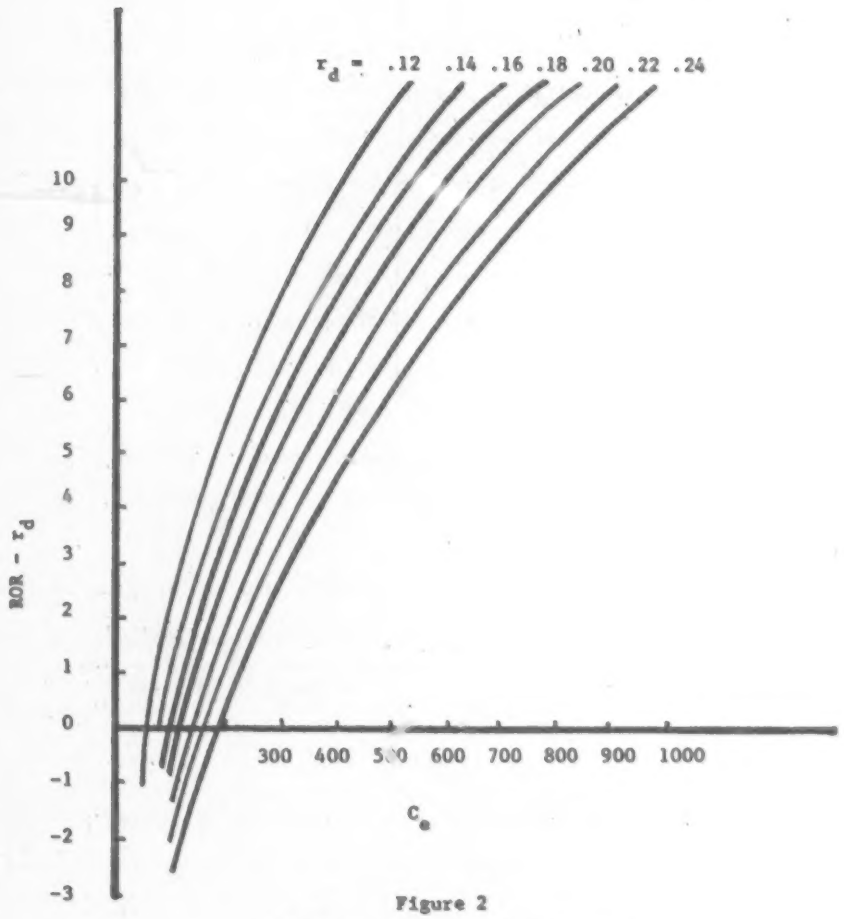

Figure 2
Investment Return After Tax Act

For the "before" Tax Act case the investment tax credit was taken as 0.1 (10%) and the depreciation life as 15 years. For the "after" Tax Act case the investment tax credit was taken as 0.2 (20%) and the depreciation life as five years.

If the hurdle rate is 10 points over the discount rate (ROR - r_d = 10), Figure 3 plots the required dollar return on a $1,000 investment as a function of the discount rate for both cases. Analysis of this figure provides insight into the strength of the Tax Act in motivating corporations to make investment in energy savings equipment. A corporation whose discount rate was 14 percent last January would have to return $580 (point 1) per year on a $1,000 investment to achieve the required hurdle rate. Today, after the Tax Act, (assuming r_d had not increased) the same hurdle rate could be achieved with $480 annual return (point 2). If, however, the discount rate had increased to 16 percent, a $535 annual return on the investment would be required (point 3). Thus an increase in interest rate (as reflected in the discount rate) of 2 points cuts the Administration's enacted tax advantages in half. It is this factor which has been instrumental in slowing industry's response to the Tax Act. Even the perception of future increases in interest rates causes the industrial sector to "wait and see".

This discussion has been hypothetical up to this point. It is possible, however, to lend credence to the derived data by examining a specific point. In January 1981 a spokesman of Union Carbide Corporation (ref. 4) stated that his company was willing to invest $18,000 capital to save one barrel of oil equivalent per day. Using an average contract price

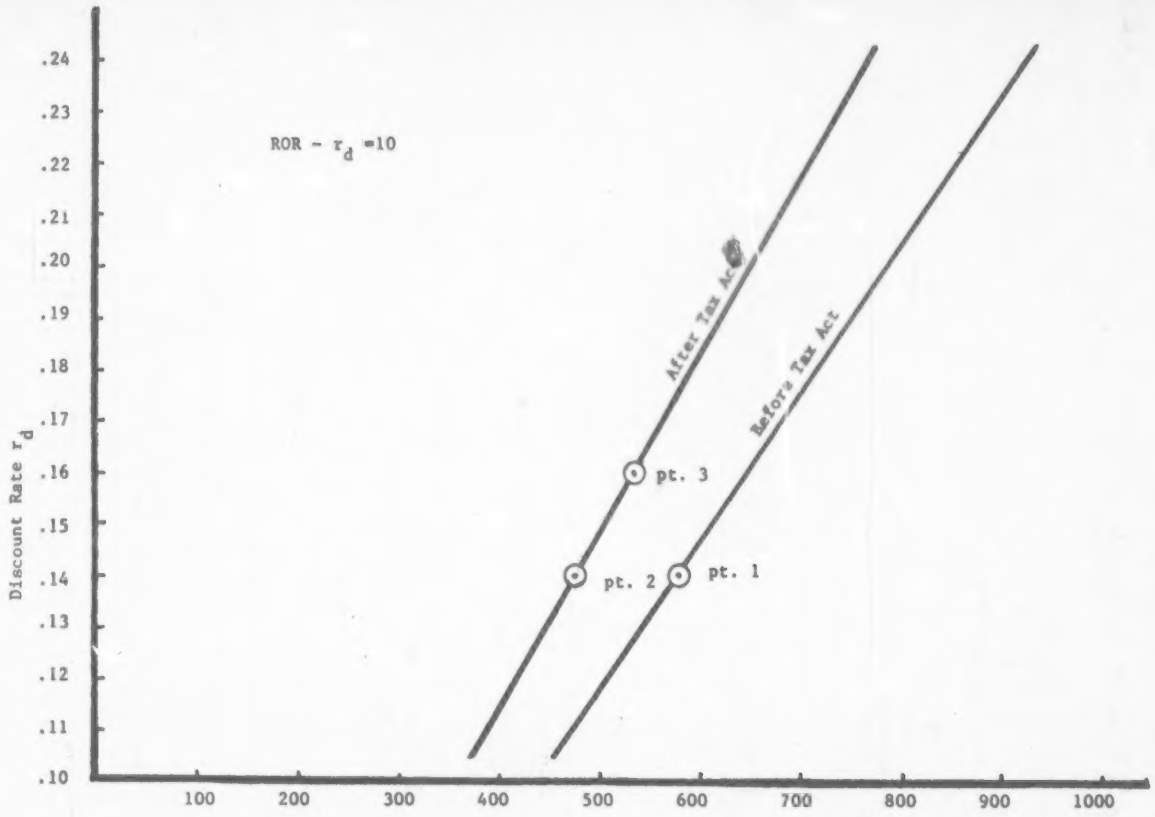

Figure 3. Return required on $ 1000 investment vs discount rate when ROR - r_d = 10.0

961

of $35 per barrel of oil equivalent and assuming it takes 10 percent ($1,800) of the investment to operate and maintain the equipment purchased, the net first year dollar return on the investment would be $10,975. The following assumptions were used:*

n = useful life = 15 years

r_e = annual increase in energy costs = 10%

T = tax rate = 46%

b = investment tax credit = 10%

m = depreciation life = 15 years

The ROR is 23.64 percent, yielding a hurdle rate about 10.7 points over the discount rate. When the investment tax credit is increased to 20 percent and the depreciation period reduced to five years, the amount that a corporation like Union Carbide would be willing to invest in a no-risk project capable of saving one barrel of oil per day equivalent would increase to $21,575, a 20 percent increase.

In January 1981, the yield on long-term Union Carbide bonds was 12.9 percent. In September 1981, that yield was 14.9 percent (representing an increase in the cost of investment capital). This implies that the r_d over this period increased by 2 percent. This increase in the discount rate would reduce the amount of capital that Union Carbide would be willing to invest to save a barrel of oil equivalent to $19,500 (assuming

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* These parameters are the same as those used in the hypothetical case analyzed earlier except the discount rate was taken as 12.9% based on the long-term bond rate yield of Union Carbide bonds as of January 4, 1981.

the same hurdle rate prevails). This represents a 10 percent increase in the rate at which capital would be invested in proven energy saving equipment.

On equipment for which the 20 percent investment tax credit did not apply, the level of investment would be reduced to $18,600 (a 3 percent increase over current level when r_d = 14.9 percent). Thus the rapid depreciation provisions of the Economic Recovery Tax Act have relatively minor effect when interest rates are high.

It can be seen that the Tax Act has the effect of increasing the rate at which "best available technology" will be achieved ranging from 20 percent, under the most optimistic conditions (20 percent ITC, interest rates 2 percent lower than today's), to 3 percent under today's conditions (assuming only 10 percent ITC).

One other facet of the Tax Act bears attention. The relaxation of regulations regarding equipment leasing will significantly stimulate third party investment in debt/profit limited industries (primary metals, cement, glass, etc.). Although third party criteria may be the same as those previously discussed, they are a great improvement over the investment criteria currently limiting these capital intensive industries (where the hurdle rate may be as high as 50 percentage points over the discount rate). It is anticipated that this provision of the Tax Act will result in significant plant modernization for these financially limited industries, and permit achievement of "best available technology" at a rate consistent with the rest of industry.

EVALUATION OF FEDERAL OPTIONS TO INDUCE INDUSTRY TO INVEST IN THE DEVELOPMENT OF HIGH RISK NEW TECHNOLOGY

Thus far this discussion has been concentrated on the response of industry to the incentives offered by the Economic Recovery Tax Act in investing in modern but proven process technology. The program mandated by Congress and conducted by DOE however, has been primarily directed towards the introduction of new, high-risk process technology potentially capable of significant improvement in energy productivity over the best available technology. It has accomplished this purpose through cost-shared projects with industry with the Federal share ranging from 40 percent (for lower risk projects with large companies) to 95 percent (for high-risk projects with small companies). The average Federal share is about 70 percent.

This section will now examine the strength of alternative techniques for achieving the introduction of high-energy efficiency, new process technologies, the reasonableness of this type of Federal investment, and the cost effectiveness of such investment.

The Relationship of Risk to Investment Decisions

A corporation would undertake RD&D in a new process only if it anticipated multiple uses internally or multiple sales externally. This is different than investing in proven technology where purchase of a single piece of equipment must yield an equivalent rate of return equal to the hurdle rate. In this case it is more appropriate to use the economic yardstick known as the internal rate of return (IRR) since multiple uses or sales implies that the income yielded from the first investment is reinvested at the same rate yielded by the first investment. This parameter can be

calculated from the equation given in Table 3 by raising the discount rate (r_d) until it exactly equals the calculated ROR.

Several economists have shown that the relationship between probability of failure (risk) and the required benefit (IRR) is an inverse function (ref. 4) expressed by the equation:

$$\frac{(IRR)a}{(IRR)n} = \frac{1}{(1-P_f)^x}$$

where

(IRR)a = the required internal rate of return, on risky projects

(IRR)n = the internal rate of return corresponding to the risk-free hurdle rate. Calculating this value using the Union Carbide investment criteria sited earlier yields (IRR)n = 51%.

P_f = the probability of failure of the project.

x = a coefficient expressing the willingness of the company to undertake risk.

The coefficient x will vary from company to company. When x = 1, the company involved would be extremely willing to accept risk and in fact would not require its risk adjusted (IRR) to be any greater than the inverse relationship accounting for failure probability.* Most companies, however, require x to be considerably greater than 1, reflecting their conservatism in undertaking R&D projects which, if unsuccessful, would

* To illustrate this point consider a company conducting 10 equivalent R&D projects each having a 50% probability of failure. When x=1, the ratio of IRRa/IRRn would be 2 for each project. At the end of the development period one half of the projects would have failed (yielding no return). The other half would succeed yielding twice the nominal IRRn. Thus, the total dollars expended on all ten projects would achieve the nominal rate of return.

have a zero return on investment. Such companies have fewer discretionary investment dollars, and thus few high risk development projects can be undertaken. The failure of any one project, therefore, significantly affects the return on the total capital pool. Thus a premium is placed on such risk as expressed by an exponent greater than 1. In 1976, IP investigated this factor and concluded that for the energy intensive process industries (quite conservative due their capital intensity), x is 2.22 or greater. Figure 4 shows the relationship between the ratio (IRR)a/(IRR)n and probability of failure for these two cases (x = 1 and x = 2.22). For a project having a 50 percent probability of failure, the corporation extremely willing to accept risk would require the projected (IRR)a to be at least twice the (IRR)n (point 1 on the x = 1 curve). In the more likely case of the risk averse process industry the projected (IRR)a to (IRR)n ratio would have to be at least 4.66 (point 2 on the x = 2.22 curve). If one can estimate the probability of failure of a given project it is possible to use these two curves to evaluate the likelihood that a corporation would undertake the project. This point is illustrated by the following hypothetical cases:

- Case 1: A corporation is evaluating an R&D project that it judges to have a probability of failure of 60% and it projects the cash flow from the project, if it were successful, to yield an (IRR)a to be 1.5 times its hurdle rate (IRR)n. This is shown as point 3 on Figure 4. Even the most adventurous firm would reject this project as too risky to undertake.

- Case 2: A second R&D project is judged to have a probability of failure of 60% but if it were successful the (IRR)a would

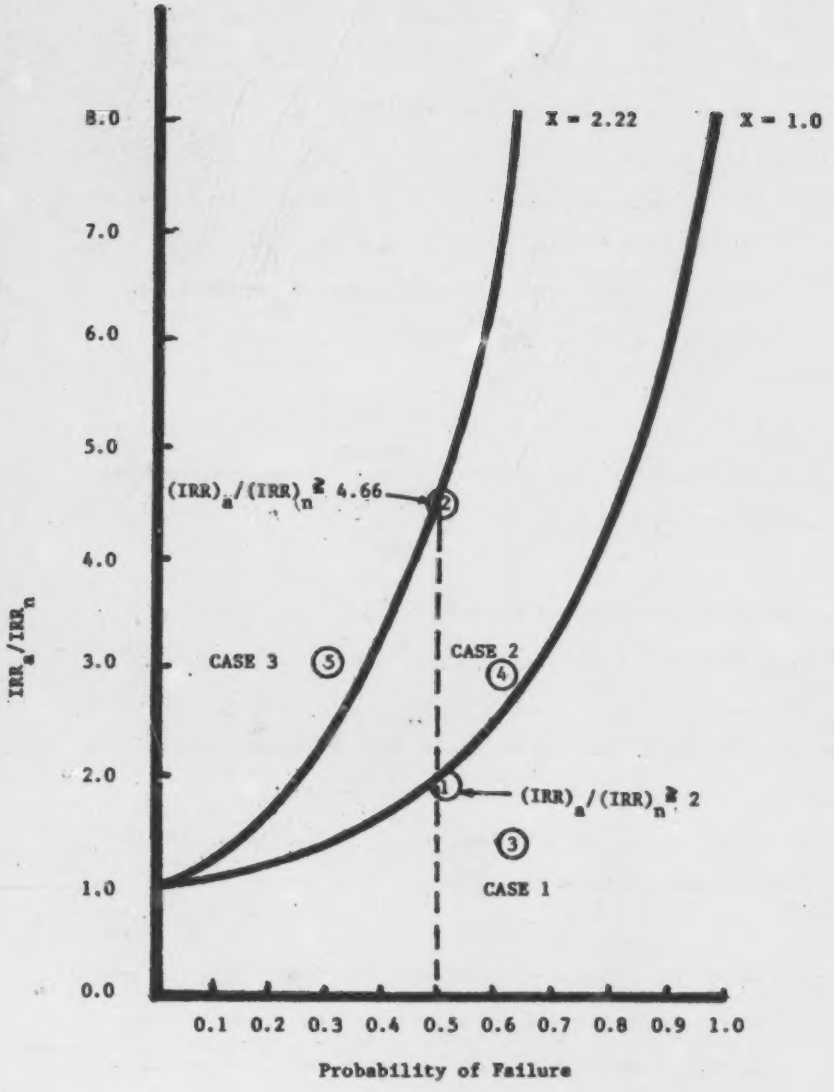

Figure 4
Ratio of IRR_a to IRR_n as a Function of Risk

be 2.5 times the hurdle rate (IRR)n. This project is shown as point 4 on Figure 4. Only a corporation extremely willing to accept risk would undertake this project.

- Case 3: A third project is judged to have a probability of failure of 30% and an (IRR)a 3 times the (IRR)n (point 5 on Figure 4). This project would probably be undertaken by even the conservative capital intensive corporation.

These tests will be used later in this paper to evaluate the strengths of various Federal options to motivate industry to undertake process research and development to save energy.

A Description of Three Federal Actions that Could Motivate Industry's Investment in Energy Efficient Process Technologies

There are a variety of options which the Federal Government could promulgate to motivate industry to improve their energy productivity through the research and development of efficient process technologies. In this paper three of these options are included. They are:

1. Permit the inducements created by the Energy Recovery Tax Act to create a climate for RD&D investment. These inducements include 5 year depreciation, 20% investment tax credit to the purchaser (not developer) of selected developed products (this is a very optimistic assumption since the 20% applies to only a few technologies) and a tax credit of 25 percent for one

half the increased RD&D expended by the developer over a base level established over the previous three years. If all new process RD&D were above the base level, this incentive would provide a 12.5 percent tax credit for such work.

2. Federal cost sharing in the development of new, high risk process technology specifically targeted to improve energy efficiency. This option represents a continuation of the activities of IP as mandated by the Non-Nuclear Energy Act of 1974.

3. Refundable Awards to the developer for introducing innovative energy productivity technologies. This is a new concept, not previously evaluated, for motivating RD&D expenditures for improved energy productivity. It is contemplated that the developer would establish the innovative nature of the process by providing evidence of a patent. The value of the energy saved would be documented by records and the developer would receive a one time cash rebate from the Government equal to one half the market value of the energy saved in the first two years after introduction, i.e., (energy saved per unit) times (number units sold) divided by 2-calculated for first two years.

Technologies Selected for Evaluation

The strength of the above Federal options to motivate industry to develop energy efficiency process technologies is tested by using four case

studies. The technologies selected for this analysis are among the projects currently under cost-shared funding by DOE. They are:

1. A slow speed diesel engine applied to cogeneration supplying 23 MW of electricity and 2000 psig steam to a chemical plant.

2. An electric driven Rankine two-stage methanol vapor compression heat pump supplying 26 million Btu/hr at 50 psi using waste heat as a heat source.

3. A ceramic recuperator capable of operating at hot side temperature up to 2500°F.

4. A high effectiveness plate fin metallic recuperator operating at hot side temperatures up to 1600°F.

These technologies were selected because they cover a broad range of failure probability, potential marketplace, and Federal cost sharing under the DOE program. They, therefore, represent a family of typical projects against which the previous cited options can be evaluated.

Probability of Failure and Projected Market Penetration

Perhaps the most difficult and controversial element in evaluating the decision to enter into an R&D project is determining the probability of failure. Many factors can cause the investment in the development of a new process to be lost, i.e., yield no return. At the initiation of a project these factors are often unforeseen, so it takes an extremely

objective impartial analyst to ask all the "what if" questions such that a reasonable value of the failure probability can be estimated. Six fundamental questions must be answered.

1. What are the technical problems that must be solved for the project to be successfully developed?

2. If the technical problems are solved what is the projected production cost, selling price, and profit to my corproation?

3. At the projected selling price and cost savings what is the equivalent rate of return to my customer (will the system sell)?

4. What is the total market for the product?

5. At the projected selling price how fast will the equipment penetrate the market?

6. Are there factors other than technical and economic that may inhibit the marketability of the product?

The evaluation of these question can lead to estimates of the technical risk, the economic risk and the institutional risk associated with the project.

The current methodology for evaluating these factors used by IP is considered circumspect by the National Materials Advisory Board (ref. 6). Consequently, a narrative methodology outlining the rationale for

judgement is used in this paper to estimate the probability of failure for each of the case study technologies.

The failure probability numbers were derived by qualitatively weighing the perceived technical, economic, and institutional problems at the initiation of the project. Considering these problems in each area a success probability and the simple relationship $P_f = (1-P_s)$ was used to calculate failure probability. Obviously, this methodology involves qualitative judgement, but it is exactly the type of judgement the private developer must make in assessing the wisdom of investing in a development program. The results of this evaluation for the four case studies are given in Table 4.

The market penetration figures were derived by using a Bass diffusion curve over 20 or 15 year periods. The curves used are shown in Figure 5. A 20 year period was used for the diesel cogeneration, electric rankine heat pump and ceramic recuperator based on the perception that these projects are significant departures from current manufacturing industry practice. The high effectiveness recuperator project was considered closer to current metallic recuperator practice, and hence, a 15 year period was used for market penetration. The penetration data are presented in Table 5.

Evaluation of Federal Options to Motivate Industry to Develop High Energy Efficiency Equipment

The four cases described are used to evaluate the strength of the three Federal options to motivate industry to develop and market new high

TABLE 4.

Probability of Failure Estimates
(as perceived at initiation of work)

	Diesel Cogeneration	Elect Rankine Heat Pump	Ceramic Recuperator	High Efficiency Recuperator
1. Technical Success Probability (P_{st})	o engine used for years in marine propulsion. o Waste heat boiler relatively standard. o Thermal/electrical interface somewhat difficult. o Environmental emissions and permitting may be problem. P_{st} = 0.99	o working fluid (methanol) seal compatibility doubtful. o Thermal breakdown of working fluid possible. o Toxicity/fire hazard with failure. o Temperature entropy map unsure. P_{st} = 0.70	o compatability of ceramic with various flue gases unknown. o Thermal shock characteristics unknown. o Casing configuration not resolved - leakage from hot to cold side a problem. o Erosion from flue particulates unknown. o P_{st} = 0.50	o Simultaneous brazing of hundreds of joints unsure. o Thermal shock characteristics of braze doubtful o Casing configuration not resolved - leakage a problem. o Corrosion of flue gases especially on braze unknown. o P_{st} = 0.50
2. Economic Success Probability (P_{se})	o Unit sales price based on good hardware values. o Magnitude of unit price may delay market penetration. o Availability and O&M costs well established. o Installation costs doubtful. P_{se} = 0.95	o Unit sales price estimate not based on final design hard- o Development costs unsure. o COP varies with heat source T. o Availability & O&M costs not known. P_{se} = 0.70	o Unit sales price estimate not based on prelim. design. o Development costs unsure. o Tooling costs for large market unsure. o O&M costs unsure. P_{se} = 0.60	o Unit sales price not sure but better than ceramic. o Development costs unsure. o Tooling costs for markets unsure. o O&M costs unsure. P_{se} = .75
3. Institutional Success Probability (P_{si})	o Current dependence of engine on liquid fuels may create user doubts on availability and realiability of supply. P_{si} = 0.90	o No institutional problems known. P_{si} = 1.0	o No institutional problems known. P_{si} = 1.0	o No institutional problems known. P_{si} = 1.0
Total Success Prob (to nearest 5%)	$P_{st} \cdot P_{se} \cdot P_{si}$ = (.99)(.95)(.90) = 0.85	$P_{st} \cdot P_{se} \cdot P_{si}$ = (.70)(.70)(1.0) = 0.50	$P_{st} \cdot P_{se} \cdot P_{si}$ = (.50)(.60)(1.0) = 0.30	$P_{st} \cdot P_{se} P_{si}$ = (.50)(.75)(1.0) = 0.40
	0.85	0.50	0.70	0.60

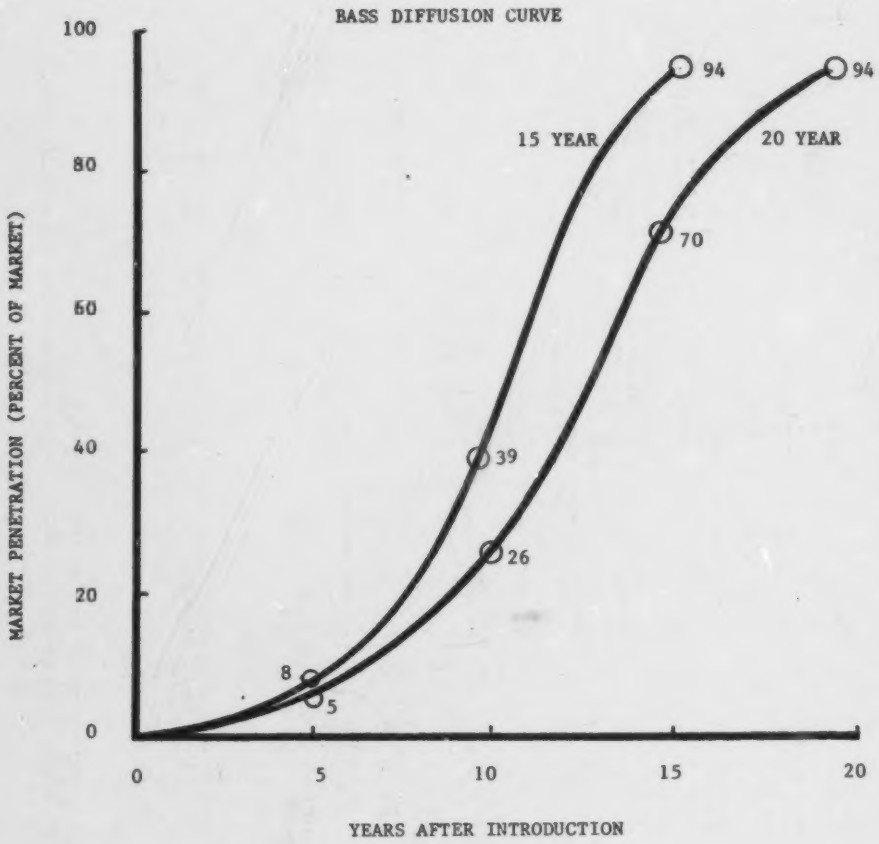

Figure 5. Bass Model Diffusion Curve Used to Project Technology Impacts

Table 5

Estimate of Market Penetration
(over 10 yrs After Development Complete)

	Diesel Cogeneraton		Elect. Rankine Ht. Pump		Ceramic Recuperator		High Effectiveness Recuperator	
Total Market (from Project Eval Sheets)	700		1,200		8,700		64,000	
Year	Units/yr	Total Units sold	Units/yr	Total Units Sold	Units/yr	Total Units Sold	Units/yr	Total Units Sold
1	1	1	3	3	400	400	400	400
2	1	2	6	9	600	1000	600	1000
3	2	4	12	21	900	1900	900	1900
4	3	7	18	39	1200	3100	1200	3100
5	5	12	24	63	1600	4700	1600	4700
6	8	20	32	95	2000	6700	2000	6700
7	16	36	42	137	2610	9310	2610	9310
8	28	64	51	188	3480	12790	3480	12790
9	35	99	63	251	4350	17140	4350	17140
10	49	148	86	337	6090	23,230	6090	23,230
10 year percent saturation of market	21%		28%		27%		36%	
Penetration curve Lifetime	20 yrs		20 yrs		20 yrs		15 yrs	

efficiency equipment. In this evaluation the cost benefit to all parties at interest (the developer, the eventual user, and the Federal government) is determined and compared with standards established earlier. Using such tests, conclusions regarding whether or not such projects would have been undertaken will be drawn.

Table 6 considers the cost benefit to the developer. The lines 7a, b, and c show the internal rate of return to the developer under the three options discussed earlier. Using the no risk (IRR)n of 51% derived earlier it is possible to evaluate (IRR)a/IRRn for each option. These data are summarized below:

TABLE 7. SUMMARY OF IRRa/IRRn FOR EACH FEDERAL OPTION

	IRRa/IRRn			
Option	Diesel Cogen	Electric Heat Pump	Ceramic Recuperator	High Effect. Recuperator
a. Allow National Recovery Tax Act to Motivate	0.705	.96	1.19	0.81
b. Cost Share RD&D	0.81	1.83	3.44	2.78
c. Federal Bonus Plan	0.74	1.46	2.67	1.15
Probability of Failure	0.15	0.50	0.70	0.60

Figure 6 plots these data and also plots the x=1 indifference curve (the locus of points above which a corporation extremely willing to accept risk will probably conduct RD&D). Comparison of the points with this line provides insight into the motivating power of the three options. The following conclusions are drawn:

TABLE 6
COST BENEFIT TO THE DEVELOPER

PARAMETER	PROJECT: DIESEL COGENERATION	ELECTRIC RANKINE HEAT PUMP	CERAMIC RECUPERATOR	HIGH EFFECTIVENESS METALLIC RECUPERATOR
1. Estimated Development[1] Cost	$22 million	$3.265 million	2.3 million	1.475 million
Federal Share[1]	8.48 million	2 million	2.1 million	1.3
Private Share[1]	13.26 million	1.265 million	.2 million	.164 million
2. Time of Development[1]	5 years	7 years	4 years	4 years
3. Future Value of Development Costs at start of market introduction[2]	27.2 million	4.56 million	2.69 million	1.7 million
Federal Share	9.7 million	2.93 million	2.45 million	1.52 million
Private Share	17.5 million	1.63 million	.24 million	.18 million
4. Tooling Costs for Production[3]	0	0	.20 million	.10 million
5. Profit Per Unit Sold[4]	1.0 million	0.06 million	.0013 million	.0006 million

6. Cash Flow Per Year[5]	Units Sold	$(mill)	Units Sold	$(mill)	Units Sold	$	Units Sold	$
Year 1	1	1.00 5.23(8)	3	.18 3.99(8)	400	.52 3.64(8)	400	.29 .66(8)
2	1	1.10 5.75	6	.40 4.47	600	.85 6.0	600	.40 1.10
3	2	2.42	12	.87	900	1.42	900	.65
4	3	3.99	18	1.44	1200	2.07	1200	.96
5	5	7.30	24	2.10	1600	3.04	1600	1.40
6	8	12.88	32	3.09	2000	4.19	2000	1.9
7		28.32	42	9.46	2610	6.0	2610	2.8
8	28	32.20	51	6.0	3980	8.6	3980	4.1
9	35	74.90	63	8.1	4350	12.1	4350	5.6
10	49	115.64	86	12.2	6090	18.1	6090	8.6

7. Internal Rate of Return to Developer				
a. En. Rec. & Tax Act[6]	36.1%	49.21%	60.9%	41.4%
b. Federal Cost Sharing[7]	41.4%	93.6%	175.6%	142.0%
c. Fed. Bonus Plan[8]	37.3%	74.7%	136.1%	58.9%
8. Probability of Failure[9]	.15	.5	.7	.6
9. Risk Adjusted $(IRR)_a$ x=2.22	71.7%	249%	767%	405%
Required if: x=1.0	62.4%	106%	176%	132%

NOTES:
1. Data obtained from IP. Project Data Sheets.
2. Based on 10% inflation figure from time development $ are spent to start of market penetration.
3. No tooling costs assumed for diesel since equipment already being built. Other values are estimated.
4. Profit per unit based on 10% of projected selling price (obtained from IP Data Sheets).
5. Market Penetration from Table 4. Cash based on profit per unit times 10% inflation factor per year.
6. Based on 87.5% times the future value of the total Development Cost plus tooling costs.
7. Based on future value of private share of Development Costs plus tooling costs.
8. Based on future value of total cost plus tooling cost as invested. First two year cash flow increased by 1/2 value of energy saved.
9. From Table 3.

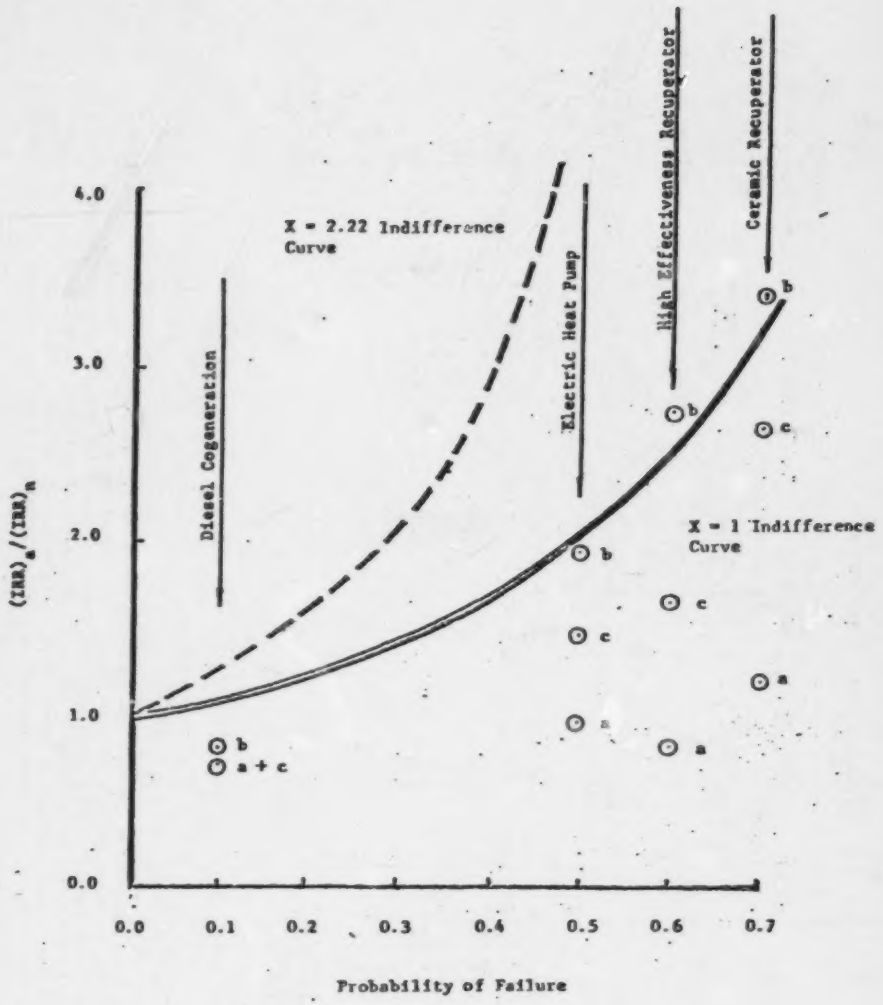

Figure 6

Test of Strength of Options a,b, and c by Comparing IRR_a/IRR_n to the X = 1 Indifference Curve.

Option a: The National Recovery and Tax Act does not provide sufficient motivation to induce even the most risk taking industry to undertake RD&D in energy productivity projects. This becomes acutely apparent as the probability of failure increases (compare points (a) with the x=1 indifference curve).

Option b: Federal cost sharing of RD&D projects as currently conducted by IP brings the IRRa/IRRn ratio of the projects studied very close to the x=1 indifference curve providing the necessary motivation to induce corporations very willing to accept risk to undertake like energy process development projects. It is the only option studied which achieves this goal.

Option c: The Federal bonus plan has significant potential of providing the necessary motivation. As configured in this paper it is not sufficient but increasing the award value and time period given may be an interesting non-intrusive alternative to direct cost sharing. Its administration may be difficult, however.

Benefits of Advanced Process Development
to the Using Industry

The corporation which purchases the successfully developed equipment derives benefit from such development only if the device provides an equivalent rate of return (ROR) equal to or greater than the corporate hurdle rate. Table 8 compares the ROR for the four cases based on

Table 8

Estimated Equivalant Rate of Return to User of New Equipment Project

	Diesel Cogeneration	Electric Rankin Heat Pump	Ceramic Recuperator	High Effectiveness Recuperator
1. Projected Sales Price[2]	$10.72 million	$.705 million	$.0125 million	$5 thousand
2. Projected Installation Cost [1]	1.35 million	.675 million	.0035 million	1 thousand
3. Total Unit Cost to User	$13.07 million	$1.38 million	$0.16 million	$6 thousand
4. Projected Value of Energy saved per Unit per year	8.43 million	$.617 million	$.0078 million	$2.12 thousand
5. ROR to user [2]	26.36%	23.6%	24.2%	22%
6. Hurdle rate ROR[3]	25.0%	25.0%	25.0%	25%

Notes

1. From Project Data Sheets
2. Calculated using Energy Recovery Tax Act provisions (20% ITC and 5 year depreciation)
3. Based on earlier calculations for proven technology

projected sales price, installation costs and estimated savings. It is seen that each project has an ROR of the order of the hurdle rate ROR established by Union Carbide data and probably will be acceptable in the marketplace.

Benefits of Advanced Process Development
to the Federal Government

An often overlooked aspect of increasing industrial energy productivity is the direct cash benefit that accrues to the Federal Government. As has been previously stated the direct cost sharing of high risk development projects is the only option studied capable of providing motivation to the developer. The taxpayer, however, deserves a return on his investment in such projects, and indeed he gets it. This return occurs because increasing energy productivity directly increases the profits of the corporation using the process and the use increases the taxes paid by that corporation. To analyze the value of this return it is necessary to determine: the total number of units in operation, the dollar value of the energy saved per unit, and the probable taxes paid by the corporations using the equipment. The first two factors can be easily obtained from the project description sheets and market penetration curves. The third factor requires an estimate of the percentage of the savings paid in taxes. A corporation normally pays 46% income tax on profits. A conservative approach, however, to determining the return to the treasury is to assume that a portion of the total increase in productivity is passed on to the consumer as lower costs. Thus it has been assumed that only 20% of the increased profits arising from each process introduction is returned to the treasury.

Since, in the cost sharing program a number of projects will fail, the return anticipated from any given project, must be discounted to account for this probability of failure. The risk discounted IRR accuring to the Treasury for the four cases studied are given in Table 9. It is observed that the risk adjusted IRR to the Treasury ranges from 27% to 78% for these projects. This represents a return on investment rarely seen for the expenditure of Federal funds. Assuming an average failure rate of 40% across all projects funded and an average unadjusted IRR of 92%*, the risk adjusted IRR is 38%. The tax payer is receiving a 38% return on his investment each year, and at the same time significantly reducing the nation's dependence on foreign energy.

It can be argued that the purchaser of the advanced equipment would have invested that capital ir other investment opportunities yielding the same ROR were this newly developed equipment not available. Thus, such advocates would say, that the return to the Federal government is not increased by cost shared RD&D. This argument is countered by the following logic:

- The number of discretionary investment opportunities directly related to improved energy productivity which yield the hurdle rate ROR of 25% is relatively limited.

- The alternative investment opportunities yielding the required ROR are not necessarily related to energy productivity, e.g.,

* Calculated using the total Federal investments and cash flows for the case studies (excluding the diesel congeneration project which is considered to be too profitable to the Federal government to be considered typical).

Table 9.

IRR to Federal Governmnt Based on their Cost Share in Development Projects Projects

1. Cash Flow to Federal Government[1] Year	Diesel Cogeneration Cumulative Units in year (#)	Diesel Cogeneration Cash Flow Treasury (millions)	Electric Rankin Heat Pump Cumulative Units in year (#)	Electric Rankin Heat Pump Cash Flow Treasury (millions)	Ceramic Recuperator Cumulative Units in year (#)	Ceramic Recuperator Cash Flow Treasury (millions)	High Effectiveness Metallic Recuperator Cumulative Units year (#)	High Effectiveness Metallic Recuperator Cash Flow Treasury (millions)
1	1	1.5	3	.63	400	0.62	400	.17
2	2	3.53	9	1.64	1000	1.72	1000	.45
3	4	7.67	21	3.34	1900	3.59	1900	.91
4	7	14.33	39	5.83	3100	5.32	3100	1.57
5	12	26.63	63	9.47	4700	10.70	4700	2.55
6	20	48.33	95	14.49	6700	16.83	6700	3.91
7	36	96.13	137	21.7	9310	25.71	9310	5.85
8	64	176.1	188	32.3	12710	38.66	12710	8.71
9	99	302.0	239	46.8	17060	56.95	17060	12.61
10	148	497.0	325	69.2	23150	84.87	23150	18.65
Future Value of Fed Cost Share at start of market introduction	$9.68 million		$2.93 million		$2.43 million		$1.53 million	
IRR to Fed Treasury	91.3%		90.7%		104%		68%	
Risk Discounted IRR X = 1	77.6%		45.4%		31.3%		27.2%	

Notes:

1. Cash flow to treasury calculated by determining total energy saved by all users in each year - calculating total value of energy saved (using 10% inflaton per year) and assuming 20% of cash value is returned to treasury in taxes (remainer of savings go to reduced price of product and to profit of company).

886

purchase of an oil company by a steel company, or a car rental business by a retailer.

- Although the return to the Federal government may be the same for corporate investments not related to improved energy productivity such return is not attributable to a reduction in energy demand, a major national goal.

- The reduction in energy demand is exactly equivalent to increase in energy supply. Thus to accurately assess the relative worth of the Federal investment in cost shared RD&D to improve energy productivity it should be compared with the Federal investment in energy supply.

There are two types of subsidy the Federal government provides for the production of oil and gas - an exploration and development subsidy and a depletion allowance. The first of these is analogous to permitting expensing RD&D costs in the energy consuming industries and will not be considered here. The second, however, is a subsidy which has no direct analogy in the energy consuming industries.

The depletion allowance may take one of two forms - cost depletion or percentage depletion (ref. 7). Cost depletion pro-rates the allowance based on the annual production divided by the total reserve in a deposit, while percentage depletion permits an allowable percent of the gross sales price of the commodity to be deducted from the revenues. For oil production the percentage depletion is usually applied. The allowable depletion formula for oil and gas is as follows:

1981	-	20%
1982	-	18%
1983	-	16%
1984	-	15%
Future years	-	15%

In no case may the allowable percentage exceed 50% (65% for independent producers) of the taxable income from the property. Percentage depletion may be used as long as the property is producing even though the basis of the property may be reduced to zero through prior depletion.

To calculate the return on investment to the Federal government, a hypothetical new oil well will be postulated. The following assumptions will be made:

- The new well produces initially 1000 barrels of crude oil per day, but the calculation will be based on a per barrel basis.
- The production from the well will decrease linearly by 5% of its initial production, per year as the oil is extracted. This is consistent with published data that the average production from a well after ten years is one half the initial production (ref. 9).

- The well head price of the crude oil is $35.00 per barrel in 1981, but increases 10% per year in succeeding years (consistent with previous calculations of IRR for consuming industries).

- The 1979 pretax profit to the producing company is 12.4% and the company's tax rate is 46%, yielding a 5.7% net profit after taxes (ref.8). These numbers are based on a 1979 average well head price of oil of $12.64 (ref. 9) based on constant 1972 dollars.

- The pretax profits on the new well under consideration is 18% obtained by applying the 1980 GNP deflator (13% greater than the 1979 deflator of 165.5 or 187) to the $35.00 well head price.

Table 10 calculates the IRR to the Federal government over a ten year period (consistent with previous calculations) for the depletion allowance investment. This IRR of 28.27% compares with the risk adjusted average Federal IRR of 38% for cost shared RD&D supplied to the consuming industries. It is concluded that the investment in RD&D to save energy is significantly better than the investment to improve energy supply and does not deplete oil and gas reserves.

Due to its unique ability to tax corporate profits, the government is the only party that can receive this cost benefit. Neither the developer not the user can reap the benefit associated with the cumulative sales of energy efficient equipment. Since each benefit is

TABLE 10
IRR TO FEDERAL GOVERNMENT ON NEW OIL WELL
(based on depletion allowance per barrel produced)

Year	bbls Produced(1)	Inflation Factor	Gross Sales($)	Pretax Profit$(18%)	Depletion Allowance 50%Test(2) $	Allowable Percentage	$Allowance based on %(3)	Allowance $(4)	Sales less Depletion $	Tax(5) Income $	Net Cash Flow to Govt.$(6)
1981	1.0	1.0	35.00	6.30	3.15	20	3.22	3.15	31.85	2.63	-0.51
1982	0.95	1.1	36.75	6.62	3.31	18	3.04	3.04	33.71	2.79	-0.25
1983	0.90	1.21	38.12	6.86	3.43	16	2.80	2.80	35.32	2.92	+0.12
1984	0.85	1.33	39.57	7.12	3.56	15	2.73	2.73	36.84	3.05	+0.32
1985	0.80	1.46	40.88	7.36	3.68	15	2.82	2.82	38.06	3.15	+0.33
1986	0.75	1.61	42.26	7.61	3.80	15	2.92	2.92	29.34	3.25	+0.34
1987	0.70	1.77	43.37	7.81	3.90	15	2.99	2.99	40.38	3.34	+0.35
1988	0.65	1.95	44.36	7.98	3.99	15	3.06	3.06	41.30	3.42	+0.36
1989	0.60	2.14	44.94	8.09	4.04	15	3.10	3.10	41.84	3.46	+0.36
1990	0.55	2.36	45.43	8.18	4.09	15	3.13	3.13	42.30	3.50	+0.37
1991	0.50	2.59	45.32	8.16	4.08	15	3.12	3.12	42.20	3.49	+0.37
										IRR =	28.27

(1) Assumes production decreases linearly such that production after 10 years is one half initial production.
(2) Calculated maximum dollar depletion allowed as 50% of pretax profits.
(3) Calculated dollar depletion allowed based on percent allowable times sales times tax rate (46%).
(4) Selects lesser of 2 or 3.
(5) Based on gross sales less depletion times pretax profit (18%) times tax rate (46%).
(6) Calculated by tax income minus depletion.

of great importance to the nation in terms of reduced energy demand, it is only logical and equitable that the government expend the funds in cost shared RD&D which enables the benefit to be realized.

CONCLUSIONS AND RECOMMENDATIONS

The preceding analysis has shown:

1. The incentives offered by the Economic Recovery Tax Act will provide industry with some incentive to increase the rate at which best available technology is introduced. The increased rate ranges between 3 and 20 percent depending on the discount rate.

2. The interest rate is a far more important factor than the Tax Act itself in accelerating the rate at which best available technology is introduced.

3. In the absence of direct Federal cost sharing in RD&D projects there are no incentives enacted or contemplated which would significantly accelerate RD&D in high risk new technology to improve energy productivity.

4. The cost effectiveness to the Federal government of cost shared RD&D is extremely high, averaging a 38% return per year on all monies invested after discounting for risk.

THE AMERICAN INSTITUTE OF ARCHITECTS
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David Olan Meeker, Jr., FAIA
Executive Vice President

April 14, 1982

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development and
Applications
Committee on Science and Technology
B374 Rayburn House Office Building
Washington, DC 20515

Dear Representative Fuqua:

On behalf of The American Institute of Architects, I am submitting a copy of the Building Energy Research program, a proposal for a comprehensive research program that will facilitate the examination of buildings as dynamic, integrated energy systems. This proposal has been developed by a coalition of building industry and public interest groups.

I am requesting that the Building Energy Research Program be included in the March 11, 9182 hearing record of the Subcommittee on Energy Development and Applications for the FY 1983 Authorization for the Department of Energy's Conservation Research and Development Programs.

Thank you for the opportunity to present this proposal.

Sincerely,

David O. Meeker, FAIA
Executive Vice President

1735 New York Avenue, N.W., Washington, D.C. 20006 (202) 626-7300

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Solar Lobby
1001 Connecticut Avenue, NW, Suite 510
Washington, D.C. 20036
202-466-6350

April 19, 1982

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development
and Applications
Committee on Science and Technology
United States House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman,

Enclosed is a proposal for a Federal Building Energy Research Program, representing an integrated approach to the technical and institutional issues surrounding energy use in buildings.

This proposal was developed by representatives of a number of groups with a wide range of perspectives on the buildings sector.

On behalf of the Solar Lobby, I am requesting that this proposal be included in the record of the Subcommittee's hearings on the fiscal year 1983 budget for the Department of Energy's Conservation and Renewable Energy Programs. I appreciate the opportunity to submit this for your consideration. I hope that you and the other members of the Subcommittee and of the Congress find it of interest and value. If you or your staff have any questions regarding this, please contact Sam Enfield at 466-6350.

With best regards.

Sincerely,

Scott Sklar
Political Director

SS/pv

Enclosure

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BUILDING OWNERS AND MANAGERS ASSOCIATION INTERNATIONAL
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202-638-2929

May 6, 1982

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development and Applications
Committee on Science and Technology
B374 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

Building Owners and Managers Association International (BOMA) International is an association of owners and managers of commercial office buildings. Our membership consists of over 5,000 individuals in over 70 U.S. and foreign cities representing over two billion square feet of commercial office space. BOMA International is widely recognized as the spokesman for the office building industry.

BOMA International has joined with other sectors of the building industry and with public interest groups to propose a comprehensive Building Energy Research Program. The goal of this program is twofold: first, to bring together for the first time all of the available building energy technology and research and make it available to the appropriate user group in all facets of the building industry (developers, architects, engineers, managers, tenants, etc.), and second, to provide a forum for developing cost-effective technology for energy conservation.

Although progress has been made within the building industry to conserve energy (through such measures as the use of effective auditing procedures, solar technology, solid state fluorescent light ballast and hot water heat pumps), we believe that much more energy can and should be conserved in buildings. It has been demonstrated that up to 40 percent of the energy a building uses can be saved through conservation. BOMA has worked diligently with Congress and the Department of Energy to develop methods by which the commercial office building industry can effectively conserve energy, thereby reducing America's dependence on foreign oil.

But in order to continue and enhance the progress that has been made, a federally-funded research program is needed. Our industry is quite decentralized, predominantly made up of many small to medium sized firms involved in building construction or in the distribution of systems and components that go into buildings. This makes it difficult for the buildings sector to alone support a comprehensive energy research program that would accomplish our goals.

I hope you will seriously consider the enclosed proposal for the Building Energy Research Program and include it in the Department of Energy's authorization bill for FY '83.

Sincerely,

Gardner S. McBride
Executive Vice President

Enclosure

75 YEARS 1907-1982

THE BUILDING ENERGY RESEARCH PROGRAM

AN INTEGRATED APPROACH TO FEDERAL RESEARCH ON BUILDING ENERGY USE

APRIL, 1982

Developed through the cooperative efforts of representatives of the following groups:

American Council for an Energy-Efficient Economy
American Institute of Architects
Brick Institute of America
Building Energy Design Tool Council
Building Owners and Managers Association International
Energy Conservation Coalition
Environmental Policy Institute
Federation of American Scientists
International Union of Bricklayers and Allied Craftsmen
National Association of Home Builders
National Association of Home Builders Research Foundation
National Home Improvement Council
Northeast Retail Lumbermen's Council
Passive Solar Industries Council
Solar Energy Industries Association
Solar Lobby

BUILDING ENERGY RESEARCH PROGRAM

SUMMARY

A number of groups, representing the buildings sector and public interest concerns, are proposing the establishment of a comprehensive and integrated Building Energy Research Program. This program would consolidate the three primary federal research and development efforts concerned with buildings-related energy technologies: the Buildings and Community Systems Energy Conservation Program and the Active and Passive Solar Heating and Cooling Programs. Combining these elements into one program will permit more efficient usage of the very limited federal funds available for building energy research. And, perhaps more importantly, it will facilitate the examination of buildings as dynamic, integrated energy systems.

A comprehensive building energy research program is essential, because buildings use over a third of the nation's energy. To date, a number of federal programs have helped the nation's building industries make progress in developing ways to reduce the consumption of energy in this sector. But these programs have been organized around individual technologies, rather than in a coordinated approach to improve the overall energy efficiency of buildings. Similarly, these programs have placed insufficient emphasis on meeting the technical and informational needs of the individuals, organizations and businesses that actually construct and use buildings.

Despite these problems, progress has been made. Expertise has been developed on how to audit residential buildings for the efficiency of their energy use. Active and passive solar technologies are evolving, which permit dramatic reductions in the use of conventional energy in buildings. New, more energy-efficient products have been successfully tested and introduced for commercial application. These steps have happened as a result of federally-sponsored research and development.

An examination of the buildings sector reveals why, in addition to its potential for energy savings, a federally-supported energy use research program is needed. The building industry is decentralized, predominantly made up of many small-to-medium-sized firms involved in building construction or in the distribution of systems and components that go into buildings. This makes it very difficult for the industry to undertake a comprehensive energy research program. Building users are likewise very diverse, including major public and private institutions, small businesses, and individual owners and renters of single family homes and apartments. A coordinated federal research program is essential to address this wide range of interests in a meaningful way and to continue the nation's progress toward real energy efficiency in buildings.

The proposed Building Energy Research Program is an integrated and comprehensive approach to energy research which meets the needs of both building owners and occupants to reduce energy comsumption and of the building industry to develop cost-effective approaches to reducing conventional energy use. Key aspects of the proposal are:

1. Buildings should be treated as integrated and dynamic energy-using systems. This approach recognizes that greater energy efficiency can be attained by appropriate coordination of various energy technologies and components within a building or between a building and a larger community-scale system or utility grid. This approach also departs from the more traditional consideration of energy conservation and active and passive solar as separate technologies.

2. The Research program should be based upon the actual behavior of occupied buildings. Once again. this represents a departure from the present programs, which mainly model the behavior of occupied buildings on computers rather than gathering empirical data on them.

3. Residential and commercial buildings should be treated separately. These buildings have different design and construction techniques, different types of energy systems, and different use patterns. Research should be structured to recognize these differences. Moreover, within each of these categories, existing buildings are treated separately from new buildings, once again because the techniques involved in retrofit applications are quite different from those in new construction. (It is important to note here that, although it is much easier to incorporate energy efficiency improvements into new buildings, the potential for overall energy savings is much greater through the upgrading of the stock of existing buildings.) Finally, multi-family buildings are recognized as a unique problem in both the residential and commercial categories.

4. The research program should be oriented toward the specific needs of those who will apply the research results, namely homebuilders, architects, engineers, appliance and product manufacturers, retrofitters, building owners and occupants. This has not been sufficiently true of the existing programs. To provide the proper orientation, this proposal calls for the direct involvement of the various members of the buildings sector in the planning and direction of the research program. This kind of partnership can ensure that the resources for energy research of the federal government and of industry will be used

most efficiently. It is important to note that considerable data on building energy technologies has been developed through the existing research programs. Even though we are suggesting the redirection of these programs, this data remains valuable, and deserves continued analysis and application within the proposed program.

5. The research program is balanced between near and long-term development work. It is unrealistic to consider that all the federal government needs to support in this area is basic research. The most promising research in the buildings sector -- with respect to energy savings -- lies with nearer-term developments. But the nature of the buildings industry, as was described, makes sole support for them by the industry as difficult as support for long-term research. As in the past, however, the industry will continue to lend its resources where appropriate to the application of technologies and strategies developed through the proposed program.

6. An ongoing component of the program should be research into the health and safety aspects of building energy systems. Recent problems with the indoor air quality of super-insulated structures suggest that attention should be given to potentially adverse side effects of new energy systems and design strategies. This kind of research is most appropriate for the federal government, which is charged with protecting the public health and safety.

The groups that have worked together to outline the Building Energy Research Program are convinced that a tightly-managed research effort can achieve substantial results if funded at a level roughly equal to the sum of funding levels authorized by Congress for fiscal year 1982 operations of the Active and Passive Solar Programs and the Buildings and Community Systems Program. We are convinced that such an investment is essential if the nation is to realize the enormous energy savings possible through improvement of the existing stock of buildings constructed when energy prices were low. We are also convinced of the importance of achieving even higher efficiencies in new buildings. While each of the representative groups might emphasize different specific needs within the research program, we all strongly support the concept of an integrated national program.

PROGRAM SCOPE

For each area of concern (residential, commercial, new and existing) the Buildings Energy Research Program should support the following types of work:

BASIC RESEARCH

Research on materials, components, and concepts fundamental to energy-efficient buildings.

APPLIED RESEARCH

Research Integration - integration of basic research elements into buildings and energy systems, and monitoring and evaluation of their performance in occupied buildings to produce an accurate understanding of energy-conserving strategies.

Prototype Development - development of systems, components and building techniques that can be used to implement energy-conserving strategies in cost-effective ways.

Institutional Research - analysis of institutional barriers that impede development and utilitzation of energy-efficient techniques in buildings, and assessment of ways to mitigate them.

TECHNOLOGY TRANSFER AND INFORMATION DISSEMINATION - packaging of program results (information on products, components, systems and innovative institutional approaches) in forms useful to the individuals, organizations and businesses that are involved in the design, construction, purchase and use of buildings (including demonstrations to prove the feasibility of innovative building products, techniques and institutional approaches).

RESEARCH NEEDS

The following is a list of important research needs in the residential and commercial buildings sector, for both new and existing stock. It is not comprehensive; it is intended to show some areas of priority.

RESIDENTIAL BUILDINGS - NEW

Basic Research

- Thermal load dynamics within buildings.
- New thermal storage and glazing materials.
- Building environmental quality (e.g. indoor air quality).
- Building materials and system controls.
- Research leading to high-efficiency appliances.
- Research leading to high-efficiency heating and cooling systems.

Applied Research

- Collection of data on thermal behavior of occupied buildings.
- Integration of solar systems with conventional heating and cooling systems.
- Collection of cost and performance data on integrated systems in various climatic regions.
- Assessment of the impact of energy efficient buildings on utility load management.
- New technologies for community-scale systems.
- Prototype development of thermal storage and building envelope materials and components, active and passive solar systems.
- Documentation and analysis of institutional decision making processes which affect the development and adoption of energy conserving strategies by end users (financial institutions, buildings owners, state and local governments).

Technology Transfer and Information Dissemination

- For homebuilders and construction trades (e.g. design innovations and construction techniques).
- For product manufactuers (e.g. performance data).
- For financial institutions (e.g. impact of energy systems and strategies on capital and operating costs).

- For building owners and occupants (e.g. operating costs).
- For local governments and utilities (e.g. innovative institutional approaches).

RESIDENTIAL BUILDINGS - EXISTING

Much of the necessary research is similar to that needed for new residential buildings. There is, however, an additional need to address the following:

Basic Research

- New retrofit materials.
- Cost-effective retrofit techniques to mitigate inflitration and conduction losses.

Applied Research

- Collection of cost and performance data on buildings before and after retrofit.
- Prototype development of packaged retrofit systems.
- Analysis of how relationships between building owners and renters affect energy decisions.

Technology Transfer and Information Dissemination

- For home owners, product and system distributors and remodelling contractors -- a much more dispersed set of industries than those involved with new buildings (e.g. retrofit manuals).
- Information on innovative delivery systems for local governments and utilities (e.g. one-stop-shop energy programs).

COMMERCIAL BUILDINGS - NEW

Basic Research

- New building shell and glazing materials (e.g. to reduce night heat loss).
- Building environmental quality (e.g. indoor air quality).
- Advanced lighting and HVAC systems and controls.
- Heat recovery systems.

Applied Research

- Analysis of energy dynamics and control strategies for complex, multi-zone buildings
- Assessment of interrelationships between active and passive heating and cooling systems (and daylighting), and their integration with conventional systems, according to various building types and climatic regions.
- Collection of cost and performance data by building type and climatic region.
- Prototype development of HVAC systems - (e.g. for individual building zones), lighting systems and strategies, heat recovery systems, and glazing systems.
- Assessment of financial and institutional factors affecting energy decisions by building owners (including concerns of financiers and occupants).

Technology Transfer and Information Dissemination

- For architects, engineers and developers (e.g. design and analysis tools that accurately predict building performance).
- For financial institutions (e.g. impact of energy systems and strategies on capital and operating costs).
- For building owners and occupants (e.g. operating costs).
- For product manufacturers (e.g. performance data).
- For local governments and utilities (e.g. innovative institutional approaches).

COMMERCIAL BUILDINGS - EXISTING

Much of the necessary research is similar to that needed for new commercial buildings. There is, however, an additional need to address the following:

APPLIED RESEARCH

- Monitoring performance of buildings before and after retrofit.
- Improvement of operating efficiency of existing systems (e.g. through improved maintenance).

- Development of more efficient HVAC and lighting retrofit strategies, and of smaller, more efficient prototype replacement systems.

- Development of energy retrofit techniques that meet other rehabilitation requirements (e.g. for fire protection, structural integrity and building safety, among others).

- Analysis of how relationships between building owners and occupants affect energy decisions.

Technology Transfer and Information Dissemination

- For architects and engineers (e.g. cost and performance data on retrofit strategies).

- For product manufacturers (e.g. product performance data).

- For utilities, local governments and energy management companies (e.g. innovative institutional approaches).

Ncat the National Center for Appropriate Technology
815 15th Street, N.W. Suite 624 Washington D.C. 20005 (202) 347-9193

Joseph F. Sedlak
Executive Director (Actg)

David J. Hoffman
Washington Director

STATEMENT OF DAVID J. HOFFMAN

ON BEHALF OF THE

NATIONAL CENTER FOR APPROPRIATE TECHNOLOGY

ON THE DEPARTMENT OF ENERGY'S

FY'83 PROPOSED ENERGY BUDGET

BEFORE THE

HOUSE SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON

ENERGY DEVELOPMENT AND APPLICATIONS

MARCH 1982

Mr. Chairman, Members of the Committee, my name is David J. Hoffman. I am Washington Director of the National Center for Appropriate Technology (NCAT). NCAT is a non-profit organization based in Butte, Montana, established in 1976 to research, develop and transfer small-scale technologies that solve the nation's energy problems. NCAT's goal is to promote the application of conservation and renewable energy technologies that can provide immediate help to individuals, organizations and communities struggling with escalating energy costs. The use of these cost-effective, small-scale technologies can help promote energy self-reliance in the United States.

NCAT has been operating since its creation with funds provided by Congress through the U.S. Community Services Administration. The founding purpose of NCAT was to apply the benefits of "appropriate technology" -- or what are often termed "soft" energy paths -- to the energy-related problems of low-income people.

The energy crisis is receding today in the wake of declining crude oil and refined product prices. But in the view of NCAT, the energy crisis may only be over until we face our next energy crisis. Many experts are warning policy makers that the crisis could come again. Congress should heed these warnings. The bitter truth is that those who fail to remember the past may be condemned to relive it.

No one knows how much of today's oil glut and downward price pressure is a temporary phenomenon. Recent history, however, must trouble us. After the 1973-1974 oil price shocks, OPEC prices only inched upwards for several years. In fact, after adjustment for inflation, they actually dropped about five percent between late 1974 and early 1979. Meanwhile, world oil demand leaped from 44 million barrels a day in 1975 to 52 million barrels in 1978.

Last year, following the 1979-1980 price increases, demand dropped to 47 million barrels a day. But if history repeats itself, the current drop in consumption and prices will be reversed sooner or later.

Quite simply, falling oil prices may put per capita energy consumption once again on a rapidly rising track. If this should happen, we risk setting in motion another chain of events that will lead to higher prices in the future. The difference between an oil glut and an oil shortage is only a few million barrels a day. If we grow

complacent as a nation, many of the recent, significant gains achieved in energy conservation and renewables may diminish. If consumers decide that the energy crisis is over, they may decide that gas guzzling is once again affordable and once again respectable.

In the last decade, we have made a good beginning as a nation in the hard task of adjusting to the end of the era of cheap and nonrenewable energy supplies. But it is only a beginning. The National Center for Appropriate Technology urges Congress not to abandon those energy programs which we define as "appropriate" -- renewable energy and conservation -- when their contribution is only just beginning to be felt.

Small-scale, "appropriate" energy technologies will deliver far greater benefits to our nation if they can be far more widely diffused and applied than at present. Many communities and individuals are already strongly attracted to principles of local reliance and self-sufficiency. Many more could be.

NCAT shares the conclusion reached in the 1981 Assessment of Technology for Local Development, conducted by the Congressional Office of Technology Assessment. In the words of OTA's director, John H. Gibbons:

> "Because AT by definition reflects local goals and values, as well as local resources and conditions, the broader adoption of AT may well lead to a more diverse and resilient economic system, but also to one that better serves the social and human needs of communities throughout the Nation."

NCAT BACKGROUND

Appropriate technology, by NCAT's definition, is small in scale and low in capital cost; by nature it creates rather than eliminates

jobs. It is defined locally by the people who use it, and because of that is inherently decentralized. It is in harmony with the environment and human health requirements. It relies on renewable energy sources. It is simple to build and maintain, and is flexible so that it can be modified by the users for maximum usefulness. Such decentralized technology if developed by the private sector will ensure sustainable economic growth.

NCAT's job has been to correlate appropriate technology with the problems facing the poor. To achieve its purpose, NCAT has developed three main strategies: (1) to determine, through research and development, which of the technologies actually worked, and just as important, which were accessible to the target group; (2) to demonstrate, through small grants to agencies serving low-income people, that the technologies could have a positive impact in solving energy related problems; and (3) to get the useful information, through publications, outreach and training programs, to anyone willing to listen and learn. This three-stage process of technology transfer has become the foundation of all NCAT activities.

1. Research & Development

NCAT's research and development staff has had some major accomplishments. From 1977 to 1979, the solar researchers developed a national reputation by producing a passive building computer simulation program. Their work stands today as an important contribution to the technical study on passive solar performance and economics. That research led to present capabilities including those to design and apply low-cost solar monitoring systems and also work with the DOE Solar Utilization, Economic Development and Employment (SUEDE) project,

among other NCAT projects focused on solar systems' efficiencies in various locations. For community action agencies venturing into the solar manufacturing and installation industry, this expertise has had a direct application in the field.

Supported by the computer simulation studies, staff architects developed a low-cost house plan making use of "superinsulation" techniques, an emerging trend in building technology. NCAT recognized that few low-income people can afford to build a new house. A main reason NCAT developed the set of plans was to show federal agencies running low-income housing subsidy programs that it is possible to build small, inexpensive houses with conservation features that drastically reduce ongoing energy costs, and yet maintain quality.

In the area of alcohol fuels, the goal has been to design a low-cost production system that would be accessible to small farmers. The prototype is complete and NCAT has shipped three site-specific variations of its design to different locations in the country in an effort to transfer this technology to those who can use it.

Other technology research at NCAT has included passive solar greenhouse design, construction and management, weatherization techniques, cold frames for gardening, small hydro generation, housing rehabilitation and community energy management. The results have been transferred to people through grants, publications and training.

2. Field Testing

Before NCAT could provide technical advice to the public, we had to develop a program to guarantee that these technologies were actually built, tested and monitored in the field for one year. We needed to be sure that the technologies would operate as well in the real world as

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in the NCAT laboratory. Blessed with strong support from the Community Services Administration, NCAT has been able to establish a foundation for appropriate technology projects in more than 350 local communities, through the provision of grant assistance to these projects.

Technology testing and demonstration efforts have also been integrated with our training and publications program. For example, in NCAT's National Technology Transfer Program for passive solar greenhouses, more than 3,000 low-income people received hands-on training in 281 community workshops, directly resulting in the construction of 101 solar greenhouses.

3. Information

The third strategy that has been at the heart of NCAT's effort is information dissemination. Getting information and skills to low-income constituencies has been a consistent, center-wide priority and the last step in the NCAT operational model.

The advantage of having 10 field representatives has been clearly instrumental to NCAT's success in this area. Not only have the outreach workers provided valuable feedback to the staff based in Montana regarding "what's what" in the field, they have also taken the lead in getting NCAT products and services to all corners of America. In four years, the field staff, along with various research personnel, have provided critical technical assistance on a.t. projects to thousands of individuals and organizations around the U.S. This service, coupled with a strong public information program operated out of the NCAT resource library in Butte, have been the mainstays of NCAT's information dissemination activities. The library, incidentally, has been developed into one of the leading a.t. resource collection in the U.S.

As for training, a program that was initiated in late 1980, NCAT has established itself as a leading a.t. training institute in the U.S. Technology transfer -- the process of teaching people how to use and benefit from technologies -- is what NCAT's training activities are all about. In 1981, that meant teaching VISTA volunteers and community action agency personnel how to weatherize homes, build low-cost solar energy devices, and conduct community energy management programs.

NCAT's idea is to transfer skills -- not just information. The goal is to train people so that they can go back into their communities and teach others. Towards that end, NCAT trainers develop programs that have an equal balance of classroom instruction and hands-on construction activity. NCAT staff have also adapted their courses to address the varying technical needs of their trainees. In other words, appropriate technology applications are site specific, and NCAT trainers design courses that cover the technologies suitable in the trainees' regions.

The publication program speaks for itself. NCAT has produced a full range of publications on conservation and renewable energy technologies. Generally, the publications have a consumer orientation with a focus on how-to information. The goal has been to keep the language simple and the booklets short and inexpensive, making the information accessible to as many people as possible. NCAT has more than 35 titles in print and distributes more than 300,000 publications per year to various constituents.

NCAT TODAY

When the Community Services Administration was abolished at the close of FY 1982, NCAT lost its principal source of federal assistance.

Last year, Congress authorized and appropriated (in the FY 1982 Interior Appropriations Act) $2.88 million to be used by the Department of Energy for the purposes of monitoring and evaluating the Department's three-year (FYs 1979-80-81) Appropriate Technology Small Grants program, and to disseminate useful information about this program as widely as possible within the technical community and to the general public.

The House Science and Technology Committee pointed out in its report on the 1982 DOE Authorization Act that a well-coordinated and integrated national effort was needed to remedy flaws in the AT Small Grants program:

> The Committee believes that the overall integration of technical oversight, information disssemination and outreach of the Appropriate Technology Small Grants Program and Small Inventors Program are inadequate. The programs have no guidance as to the state of research nor adequate research nor adequate outreach, training, information or localized/individualized technical assistance. Since Federal money is limited the Committee believes that these services should help prevent the duplication of efforts of other Federally-supported programs and assist individuals and localities seeking technical advice on developing their own energy production conservation and invention ideas. The Commiteee expects the Office of Small Scale Technology and the Office of Inventions to coordinate its efforts with other Federal agencies. The Committee also recommends that the Secretary of Energy enter into appropriate negotiations to provide that existing appropriate technology research, development and demonstration programs which may be transferred or phased out of the Community Services Administration (CSA) or the National Science Foundation (NSF) program be incorporated into the Office of Small Scale Technology and Office of Inventions.

The Senate Energy Committee report reached the same conclusions in virtually identical language. In report language, the House and Senate Appropriations Committees indicated that the Department was expected to use NCAT to carry out the monitoring and information dissemination project.

Early in 1982, NCAT and the Department agreed to undertake a collaborative program to achieve these goals. In this effort, which is expected to begin in April 1982 and last for eighteen months, NCAT expects to ensure through our scientific resources and technical assistance capability that acceptable technical standards are maintained among the 2400 DOE AT grants. We also expect to mount a major technology transfer effort through consumer-oriented publications and by other means of information dissemination.

Many authorities testify to the value of federal efforts to facilitate and supplement market forces in the transition from a wasteful energy economy fueled by dwindling nonrenewable resources to one reliant upon more efficient use of such fuels and a growing emphasis upon renewable energy. The Oak Ridge National Laboratory and the General Accounting Office have recently reached such conclusions.[1] NCAT believes that much more remains to be done by the Federal Government if the promise of small-scale technologies to help produce or conserve energy is to be realized. Individual self-reliance, entrepreneurship, and community-based enterprise can flourish only when reliable technical information is available. Yet today, Americans confront a welter of conflicting and confusing claims about technologies. Without trustworthy technical information, consumers simply cannot make informed choices, and the efficacy of market forces is therefore undermined.

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1 Oak Ridge National Laboratory, Energy Saving Impacts of DOE's Conservation and Solar Programs, ORNL/TM-7690, 2 volumes, 1981; and U.S. General Accounting Office, Views on Energy Conservation and the Federal Government's Role, EMD-81-82, June 17, 1981.

Consider the conclusion of a 1981 report on appropriate technology published by the Congressional Office of Technology Assessment:

INFORMATION DISSEMINATION

> Even when a technology is fairly well developed and data have been gathered by one developer, its diffusion can be impeded if other potential developers are unaware of the project or unable to obtain detailed information on design, costs, and performance. In some cases this will cause communities to overlook a promising alternative or to waste time and money in an unnecessary duplication of efforts that have already been carried out elsewhere. In other cases it will result in resistance from engineers and financial sources who, in the absence of reliable technical and economic information, consider the project too risky. In a few cases this might cause the failure of a project because its organizers were unaware of the problems, and solutions, that have been discovered in similar projects elsewhere.

NCAT TOMORROW

NCAT urges Congress to take a significant step to realize the potential further contribution which small-scale, appropriate technologies can make during the course of the 1980s as individuals, organizations, and communities seek practical means to help themselves. Many communities, for example, are developing self-help energy programs but are uncertain of which energy technology to make use to provide the biggest BTU bang for the buck. No federal program currently provides technical design review and individually specific information to help inventors, entrepreneurs, and community officials. Other federal information programs -- such as CAREIRS, the Conservation and Renewable Energy Inquiry and Referral Service -- merely provide product referrals and an assortment of publications. But publications and referrals cannot provide the detailed level of information needed for a do-it-ourselves decision at the local level.

NCAT's five-year history in AT-related research could be applied to a NATIS program. This would ensure that high technical standards are met vis-i-vis information dissemination, ensuring that "state of the art" information is included in publications and technical assistance. NCAT's outreach and training capabilities would ensure that correct, locally relevant technical referrals are made when requested.

NCAT believes that we have in the past only brushed the surface of the potential demand for consumer-oriented technical information to aid people in the application of energy-related technologies. Many Americans today puzzle over how best to insulate their residences, use locally-appropriate passive solar design in home building or remodeling, or apply alcohol fuel systems at the community or small farm level. We believe that a nationally recognized center, to which such people could turn for information and technical assistance, would quickly be inundated with inquiries.

CONCLUSION

The establishment of a National Appropriate Technology Information Service -- with its initial efforts devoted to energy -- would signal a major federal commitment to spreading usable information to the American people. In the words of the Worldwatch Institute study, Helping Ourselves: Local Solutions to Global Problems: "The most important thing that government can do is to provide information and technical expertise at the local level, making it easier for citizens to help themselves."[2] A national energy strategy resting on individual and community initiatives is indeed "a great leap made up of a series of small steps." The creation of NATIS would be a significant move in this direction. A mandate to begin awaits the action of Congress.

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[2] Bruce Stokes, Helping Ourselves: Local Solutions to Global Problems, A Worldwatch Institute Book (New York: Norton, 1981), pp. 56,58

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RALPH J. JOHNSON
President

March 16, 1982

Dr. Eugene Frankel
Committee on Science and
Technology
Subcommittee on Energy
Development and Applications
Room B-374
Rayburn House Office Building
U.S. House of Representatives
Washington, D.C. 20515

Dear Dr. Frankel:

I had wanted to include in my testimony before the Subcommittee on Energy Development and Application of the Committee on Science and Technology on March 11, some comments on research for active solar space and water heating. The statement was so long however, that I elected not to do so.

In the meantime, I have given more thought to the subject and would like to add the following comments to my previous testimony. Whether the Committee elects to make it a part of the record is of course, up to the Chairman, but I would like to convey the following thoughts to you.

The following remarks are based not only on my own views, but the views of some leaders from both the academia and from the side of the hard realities of solar system manufacture and sale.

It is well known that industries dealing with mature technologies know that survival means continuing research and development. They know they must, in order to stay competitive, improve their products to avoid obsolesence. For example, I suspect that more money is being spent today on improving gas and oil furnace efficiencies than in any time in the past.

For a new technology, such as active solar space and water heating, the need for research and development is even greater. The products being sold today by the industry are expensive and imperfect. Competition with conventional sources of energy is difficult. Product improvements and cost reductions are desperately needed. But the struggle of the industry to survive in these early stages of its existence severely

restricts the availability of capital for product improvement. In short, research and development are not supportable with the funds generated by the solar industry. Product improvement is therefore deferred by most solar equipment manufacturers with the inevitable result that product quality does not improve and costs do not come down.

The solar heating industry, including manufacturing and installing, is estimated to be about a one-half billion dollar a year industry. So even if research were to average only 3%, that would be $15,000,000 a year. It seems to me that the embryonic stage of the industry and the national long range interest justifies even more research funding for cost reductions and product improvement.

The case for federal support of research and development in solar heating is compelling. Without such support, the technology will stagnate at present levels. Improvements will be slow and cost reductions unlikely. When the federal solar tax credit expires in 1985 (unless it is prematurely discontinued), the industry will be unable to suddenly meet the competition from gas, oil, and electric heating. Only by concerted and creative research and development can competition be achieved.

Some argue that the solar heating industry is well on its way and government support of research and development is no longer needed. Others say that there are very few, if any, areas of needed and productive research and development in solar hot water and solar space heating technology. Both of these viewpoints are erroneous.

To illustrate and emphasize the needs and opportunities for cost reduction and performance improvement in solar heating systems, I suggest the following examples of needed R&D projects:

1. Determine the performance improvements that can be obtained by using variable air flow rates in solar air heating systems, and develop the most economical methods for this type of operation.

2. Develop standardized, complete, factory-assembled operating "packages", comprising pumps, blowers, heat exchangers, tanks (or tank sections), valves, dampers, connections, and controls, for space heating with air and liquid systems, thereby reducing fabrication and installation costs.

3. Make improvements, that are clearly possible, in solar heating and auxiliary heating control strategy and in the controls themselves, thereby improving efficiency and reducing system cost.

4. Carry out definitive analyses, followed by experimental verification, of economically optimized heat storage capacity, as affected by climate, fuel price, and storage system cost.

5. Develop improved solar collector designs and materials so that the cost of delivered solar heat can be substantially reduced.

The foregoing topics represent a few of a great many research and development needs in the solar heating field. Most of them pertain to systems rather than to specific components, because it has not been practical for manufacturing industry to fabricate or market integrated, "packaged" systems. Inexperienced designers and installers have therefore usually selected and assembled the various components into systems, many of which are inefficient and costly. So, systems R&D is critically needed for solar heating to become fully competitive with conventional sources. Federal support of capable and experienced scientists and engineers, in universities, research organizations, and in industry itself is required for this technology to be made available for wide use.

Even in a poor U.S. solar climate, about half a million Btu are received on a square foot of solar collector each year, but only one hundred thousand Btu are typically delivered for use. With achievable improvements in design, control, and operation, these low solar efficiencies can be doubled. By so doing, solar heat costs are cut in half. The nation deserves the benefits of such improvements. A committment of modest funds, about the FY '82 level each year for three more years or so, can achieve these objectives.

Sincerely yours,

Ralph J. Johnson

RJJ:nmo

MICHIGAN STATE UNIVERSITY

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March 1, 1982

Don Fuqua, Chairman
Science and Technology Committee
U.S. House of Representatives
Washington, D.C. 20515

Dear Congressman Fuqua:

We understand that your committee will hold hearings this week on the Department of Energy. As reported in the newspaper, Secretary of Energy James Edwards testified before the Senate Committee on Energy and Natural Resources that increased energy costs "have fostered substantial conservation efforts by individuals, businesses and other institutions." This is certainly true. However, the Secretary went on to conclude that "Consequently, a major Federal conservation program is no longer necessary." We disagree with the Secretary's conclusion because, while motivation to conserve exists, consumers lack adequate information to make economically rational choices.

Over the past eight years, we have been studying residential energy consumption in Michigan. As described in the enclosed papers, we find a number of impediments to more efficient energy use:

- Consumers are not very good at evaluating what is necessary for their own residences. For example, when they do not know the existing level of insulation in their houses, they most frequently assume that their houses are already adequately insulated.
- Virtually all consumers measure energy use in dollars, rather than in energy units. Thus, if prices rise after they make energy improvements, they underestimate the financial return on their energy conservation investments.
- Apart from heating and air conditioning, consumers do not have a very good idea of the relative amounts of energy used by their appliances. For example, they overestimate energy used for lighting, and underestimate the amount used for water heating. (In fact, water heating uses many times the energy of lighting.) Thus, they are likely to waste time with labor-intensive lighting management while passing up simple and highly cost-effective improvements to their water heater.

Although we can understand why mistakes such as the above are commonly made by consumers, these mistakes unfortunately impede the adoption of cost-effective improvements in energy efficiency.

For the next decade, increased efficiency in energy use offers the largest and least expensive "source" of energy. We agree with the Secretary that price rises have already helped encourage more efficient use of energy. At the same time, higher prices have imposed a greater burden on energy consumers than they did in the past. As long as consumers lack adequate access to information, home energy decisions will not be optimal either for family budgets or for the nation. The need for a strong Federal role in energy conservation has never been greater than it is today.

Sincerely,

Willett Kempton, Ph.D.
Research Associate
Family Energy Project

Peter Gladhart, Ph.D.
Co-principal Investigator
Family Energy Project

WK/PG/tr
Enclosures
cc: Gene Frankel

FOLK QUANTIFICATION OF ENERGY

Willett Kempton and Laura Montgomery

November 1981

ABSTRACT

Consumers use simplified energy measurements as a basis for residential energy decisions. Although these methods seem incorrect to an energy analyst, they are cognitively efficient. They are easy to learn, easy to calculate, and compatable with general-purpose budgeting tasks. We analyze consumer quantification of four energy problems: comparison of fuels, changes in consumption through time, usage of individual appliances, and length of payback period. Consumers make systematic quantification errors which both misdirect their planning of energy conservation actions and cause them to underestimate the benefits of previous actions.

The authors are, respectively, research associate and graduate assistant with the Family Energy Project, Institute for Family and Child Study, Michigan State University, East Lansing, MI 48824. Both authors are also affiliated with the Department of Anthropology at Michigan State University.

Michigan Agricultural Experiment Station

Journal Article No. 9987

Introduction

Consumers measure their direct energy consumption using techniques which are quite different from those of professional energy analysts. Consumer methods are understandable and are consistent with other household tasks, such as budgeting and bill paying; but they do not always lead to optimum energy decisions.

A variety of activities and devices use energy in residences, but this variety is aggregated into one or two utility bills. To disaggregate these costs, families must employ their own beliefs about each energy use. Thus, consumer energy choices are more difficult than other market decisions. Imagine a parallel situation for groceries: a store without prices on individual items, which presented only one total bill at the cash register. In such a store, the shopper could estimate item price by weight or packaging, could experiment with different purchasing patterns, or could consult consumer bulletins based on an average shopping basket. Though such cost estimation methods seem unbelievably crude for groceries, we show here that equally crude methods are indeed used to estimate household energy expenses.

This paper analyzes the quantification of energy by nonprofessionals. We call this the folk quantification of energy. The word "folk" is used to indicate the similarity of these quantification methods to folklore or folk beliefs, which are created and transmitted informally by ordinary people.

We contrast folk quantification with the methods of an energy analyst. The analyst would directly measure energy used, price per energy unit, and productive output. From these direct measures, the analyst could compute dollar cost, efficiency of energy use, and economic payback of efficiency investments. Folk methods can estimate each of these quantities. However, their results are systematically biased against many cost-effective

efficiency improvements. As a result, the consumer is unable to maximize satisfaction by optimum use of financial resources.

Consumer decisions, based on folk quantification, have a considerable impact on national energy consumption (1). These folk methods are also of theoretical interest, since their analysis applies cognitive principles to people's everyday reasoning. Therefore it is surprising that they have, to date, remained virtually unstudied.

Ethnographic Methods

To study folk quantification, we use ethnographic techniques. These techniques were developed to study foreign cultures, while minimizing the biases of the interviewer's own culture. Similarly, we used ethnographic interviews to understand folk quantification methods from the perspective of their users, rather than evaluating their correctness from the perspective of an energy expert. As in a foreign culture, we found that our background made us see issues differently from the people we interviewed. Our technical training led us to compare diverse fuel types by their energy units (joules or Btus), while consumers compared them by total dollars billed. We were trained to compare diverse appliances by their rated energy consumption, while consumers often used running time or equivalent human labor. We were trained to compute investment payback by the value of saved energy units, while most consumers computed it by change in dollars billed.

An energy expert might dismiss these folk quantification methods as inaccurate or wrong; economic models ignore them by assuming "perfect information." But these folk methods make sense to their users, are the basis of current market decisions, and will be used by consumers to interpret future energy information and advertising. Since these folk

methods have not changed as quickly as energy prices, many are counter-productive today. However, some folk methods, though they might not be used by engineers, seem to work quite well. For these reasons, we use ethnographic methods, which facilitate an understanding of folk quantification in the terms of its users.

Ethnographic methods are fully described elsewhere (2); we briefly describe our use of them here. We interviewed families in their homes (3). Our interviews did not use predefined questions; we kept within energy topics, but allowed the informants to guide much of the specific discussion (this is why interviewees are called "informants" rather than "respondents"). After the informant had talked freely for a while, we would ask questions eliciting clarification or more detail. Careful questioning often revealed that informants were using terms like "energy consumption" and "energy crisis" differently from us.

Thirty Michigan families were interviewed in 1980. Although a sample of 30 may seem small to those accustomed to survey research, small samples are typical for ethnographic work. Our intent is not to adequately sample the nation, but to illustrate common ways of thinking about energy which differ from those of energy specialists. Of the 30 families, ten were selected because they had adopted particular energy-saving devices, such as a solar system, wood heat, or bicycles. The remainder were selected from an earlier area probability sample (6) to span a range of incomes, occupations, and family types. We included equal proportions of families who had reduced energy consumption and families who had not.

Interviews were taped and transcribed. As is common in ethnographic reports, we illustrate major points with quotations from our informants.

Energy Quantity Estimated by Dollars

None of the families we interviewed used the abstract energy units of physics, such as joules or Btus, and very few used commercial units, such as kilowatt hours or Ccfs. Here we discuss folk units, those units which are familiar to, and used by, ordinary people. For example, gallons and dollars are folk units. Folk units are easily visualized, multi-purpose, and appropriately scaled. Some informants expressed a desire to use commercial units; several said "you have to look at the amount, not just the dollars." Apparently this was only a verbal recitation of advice from utility or government publications, since in practice, they rarely measured fuel directly, and often measured dollars. The significance of the dollar as a folk unit goes beyond the commonplace observation that "people care more about saving dollars than about saving energy." Cost provides more than motivation; we shall demonstrate that it is a conceptual tool.

In this section, we show how dollars are used to measure monthly energy consumption. In the following section, we illustrate use of other folk measures which disaggregate this monthly total in order to estimate usage of individual devices and activities. We will subsequently use these data to argue that dollar measurements adversely affect payback calculations.

To contrast with other fuels, we first discuss gasoline, which is more completely quantified in folk units. Its quantity is measured in gallons, its price in dollars per gallon, and its productive output in vehicle miles traveled. Dollars, gallons, and miles are all easily visualized and understood. Efficiency is quantified by miles per gallon, a ratio of two folk units. Miles per gallon is now almost universally used to characterize vehicle efficiency and consequent vehicle desirability. Gasoline's

compatability with folk units, combined with its large proportional share as a household energy expenditure, explain why public awareness of comparative efficiency is so much greater for automobiles than for other durable consumer goods, such as refrigerators, water heaters, and even homes.

None of the other fuels are as well quantified as gasoline. Fuel oil can be measured in gallons, but its productive output (degree-days of heating) does not correspond well to any folk units. Therefore, a gallon of gasoline is more meaningful (you can drive X miles on it) than a gallon of fuel oil. Still less meaningful are units of electricity and natural gas, since consumers cannot easily measure or visualize the kilowatt hour, therm, or Ccf (100 cubic feet).

Besides dollars and gallons, heating oil can be measured in folk units by using time intervals. For example, a man evaluated his home weatherization as follows: before weatherization, "the guy was coming twice a month to fill my tank up," whereas now he "only fills it up once a month." (Such interval reports apparently refer to the shortest interval of the season, during the coldest months.) Time interval measurements successfully control for price increases, though not for variations in delivery scheduling.

In our interviews, we asked informants which fuels accounted for their largest consumption of energy. They assumed that we meant consumption in dollars; if we asked for comparison of amount, not cost, we got a confused response. For example, the informant below, a heating equipment retailer, ranked heating oil as his "main use" of energy. We then asked him whether he meant that he <u>used the most</u> or it <u>cost the most</u>. He replied:

> Well, I don't know, cause I don't know how you compare the kilowatts with gallons of oil (laugh). So, I don't know, ya know, how we

> could compare something like that, but as far as money wise, yes, I definitely use more oil than I do electricity . . .

Dollars provide the only folk measure available for comparison of fuels.

Like comparisons across fuels, comparisons through time also used the folk measure, billed dollars. For example, in the following, a woman is trying to convince her husband that their insulation had reduced natural gas consumption: "Yeah, but this year we didn't have any $100 gas bills, did we? I mean we used to have $100 gas bills." People commonly made comparisons in dollars, rarely in energy units; we never heard statements like: "We used to have 250 Ccf months."

Even people who did examine fuel units found them less useful than dollars. One person reported: "I'd look at the kilowatt-hours but that doesn't mean an awful lot to me." Another said she could remember the dollar amount but not the fuel units "because you're remembering the balance in your checkbook (pause) you know, or how much it hurt to pay the bill." Dollars are easier to remember because they are meaningful, that is, they relate to other activities and computations.

Dollars are used not only for measurement, but also for interpretation of national policy. We asked one family, who had halved their fuel oil use, whether they thought their conservation actions were "a way to solve the energy crisis." They replied with an emphatic "no" explaining "it's not gonna solve the problem" until "the corporations" stop raising energy prices. This was one of several families who apparently had interpreted public statements about "the energy crisis" in terms of the crisis they experience personally--difficulty in paying monthly bills.

Written energy records were kept by a minority of the families. Only

two of these records included fuel units; Figure 1 is an excerpt from one of these two. (The other is discussed in the section on payback calculations.) Figure 1 records natural gas use, which is metered by Ccfs. Such records are unusual, and this one is especially thorough because it records Ccfs and dates as well as dollars. Nevertheless, we find a conceptual bias toward dollars even in this case. The bias toward dollars is pervasive; Figure 1 manifests it in four ways: 1) Dollars are recorded in larger lettering than Ccfs. 2) Dollars, but not Ccfs, are computed into yearly totals and monthly averages. 3) The recorded month is the month of payment, rather than the month of consumption (for example, "Jan 1976" records gas consumed from 13 November 1975 through 15 December 1975). 4) Ccfs are labelled not by name but as "Units used."

Figure 1 ABOUT HERE

The consequences of totaling and comparing by dollars is demonstrated in Table 1, which sums both Ccfs and dollars from the full household record. Gas consumption drops 10 percent between 1976 and 1977. The drop is obvious in the Ccf summations but invisible in the dollar summations.

Table 1 ABOUT HERE

The problem we describe here is due to calculation and measurement methods, not ignorance or misconception. All of our informants, including the person who kept the records of Figure 1, were keenly aware of the relationship between consumption, unit price, and billed cost. But their measures either did not use this knowledge, or used it only for rough estimations. An example of a rough estimation is provided by the following quotation, from a woman who is marshalling evidence of her neighbor's benefits from insulation:

> It [the oil bill] was going up so much a year
> and the year after they insulated they paid

> the same amount for oil as they did the year
> before they insulated.

She concludes from this evidence that the insulation "Cut their bill down." Her approximation successfully identifies a drop in consumption balanced by rising unit prices, without measuring either consumption or unit price directly.

Such methods seem awkward from the viewpoint of the energy analyst--why not just measure consumption changes directly? From the viewpoint of household management, energy quantification is one of a general class of financial quantification problems. Measurements are not optimized for the peculiarities of energy costs, nor are they optimized for specific details of housing, food, or other expenses. By measuring monthly dollars billed, the data are comparable across expenditure categories and relevant to monthly money management. In short, dollars are comprehensible folk units, they are appropriate for the purposes of home budgeting, and they are the only folk measure which can be used to compare diverse fuels. We further analyze energy measurement in dollars when we discuss payback calculations.

Disaggregating Energy Consumption

The above methods estimate aggregate monthly energy consumption. Families use other methods to disaggregate the total into individual activities and devices. Disaggregation is performed both consciously, by deliberate experiments, and unconsciously, through perceptual and cognitive factors which affect estimates of energy use. One residential energy use, lighting, provides our first example.

Residential lighting consumes a small proportion of total residential energy, but families usually list it as a major energy use. By comparison, hot water heating consumes about five times the energy of lighting (4), but

was mentioned far less frequently. Our ethnographic interviews did not quantify consumer judgments, but a 1978 survey of 400 Michigan families did, as summarized in Table 2 (5). When asked "What things do you know that a family could do to reduce the energy consumption in their house?", 59 percent listed lighting reductions while only 12 percent listed hot water reductions. When asked to estimate the annual dollar savings of each action, the average for lighting was $67, for hot water $32. Our inference of an overemphasis on lighting is also consistent with an earlier (1976) survey of actions taken: almost twice as many families reported lighting reductions as hot water reductions (6).

Table 2 ABOUT HERE

Energy professionals have demonstrated several low-cost water changes which do not affect cleaning or convenience and yield savings much greater than lighting (7). Nevertheless, people more frequently report lighting as "energy consumption," estimate lighting as saving more money, and more frequently try to change it. We show below reasons for the overemphasis on lighting, and argue that this overemphasis reduces total energy savings. Historical and cognitive reasons explain the emphasis on lighting.

Historically, the older adults of today (and the parents of younger adults) grew up when households had few electric appliances. Then, lighting consumed most of the household electricity--initially 100 percent—and electricity was more expensive (more in inflation-adjusted dollars). Therefore, lighting reductions effectively reduced electric bills.

The cognitive reasons for lighting emphasis concern perception and categorization. Perceptually, the output of lighting is more visible than other appliances—it fills the visual field. In categorization, lighting is a prototype for the category of household electricity uses. We draw the notion of prototype from cognitive psychology and cognitive anthropology;

the prototype is one specific example which is taken as being representative of a broader general category (8). As evidence that lighting is a prototype for electricity, we note that informants usually mentioned it first in lists of electrical uses, and often used it as a synonym for electricity (as in "the light bill").

The practical result of these historical and cognitive factors is that attempts to reduce electricity use will focus first and predominantly on lighting (9). These actions have limited potential. Even if residential lighting energy were halved (a reduction we consider unlikely), the average family would only realize a 70 cent reduction in their monthly bill (10). By comparison, simple and inexpensive hot water efficiency improvements would save $11.00 monthly for electric water heating or $4.80 monthly for gas (11).

Families usually reduce lighting energy by management strategies. Unlike equipment efficiency improvements, management requires no cash investment cost--but it can have high costs in attention and discipline. For example, one man wondered aloud whether it was worthwhile having to "yell at my kids and tell them to turn that light off." Further, small potential savings mean that families beginning intensive lighting management are unlikely to notice any change in monthly bills, and may conclude that energy conservation efforts are futile.

Lighting is an interesting case because it combines so many factors. Non-energy factors are also used to estimate energy use of other appliances. For example, running time was sometimes cited as evidence of high energy consumption. This is true only if differing power load is considered. Another factor which we hypothesize, based on limited data, is that the quantity of human labor replaced by a machine is used to estimate

energy consumption. We advance this hypothesis to explain why the energy use of appliances such as mixers and dishwashers seems to be overestimated (12). In this case, like lighting, cognitive factors direct families toward labor-intensive but unproductive conservation strategies.

Some families performed deliberate experiments to disaggregate energy uses. Typically, they would change an appliance or behavior and look for a change in the next utility bill. Some of these experiments seemed fairly accurate. Unfortunately, in most cases the energy change was too small to distinguish from other monthly fluctuations. For example, one family tried to watch less television, and another turned their electric range elements off a few minutes before cooking was complete. Both expressed surprise and frustration at the lack of change in their bills; the people who turned their range off early concluded "What the heck is the use of saving? You know, why try to save when it don't do any good?"

Another problem with this experimental technique is that the measurement is based on dollars billed rather than on energy units. In another unsuccessful experiment, one family noted that their electric bill went up after a plumber raised the hot water temperature. They had him turn the temperature back down, but reported: "That didn't help any." Their measurements combined price increases, water heater consumption changes, and changes in use of other appliances. We would interpret this as an experiment with too many uncontrolled variables, but the family presented it to us as further evidence for the futility of trying to save energy.

Payback Calculations

Since families quantify energy primarily in dollars, they compute financial savings differently from a business analyst. An analyst first would compute units of fuel saved, then would multiply by the marginal

price per unit of fuel. Families use a simpler calculation of savings: previous costs minus current costs. The two methods are compared algebraically as follows. For year y, we write cost as C_y, energy consumed as E_y, and price per unit as P_y. For an efficiency improvement made at the end of year 0, the saving in year 1, S_1, is computed:

expert method $$S_1 = P_1 (E_0 - E_1) \quad (1)$$

folk method $$S_1' = C_0 - C_1 \quad (1')$$

People use the folk method primarily because it uses a folk unit, dollars. It requires only a single arithmetic operation. Further, it is consistent with household money management, which is based on comparing and anticipating expenses repeated in regular billing cycles (14).

The above equations are written as they would be measured and computed under each model. Since cost is the product of price and quantity, we can rewrite Equations 1 and 1' to be more comparable:

expert method $$S_1 = P_1E_0 - P_1E_1 \quad (2)$$

folk method $$S_1' = P_0E_0 - P_1E_1 \quad (2')$$

This expansion clarifies the relationship between the two methods. With constant energy prices they yield equal results; rising prices cause the folk model to underestimate savings.

From yearly dollar savings, the payback period can be calculated in order to evaluate an energy investment. An investment, I, has a payback period of n years when the savings have repaid the initial investment:

$$I = S_1 + S_2 + \ldots + S_n \quad (3)$$

This is called simple payback to distinguish it from more comprehensive methods which adjust for inflation, depreciation, and the time value of money. Since it does not consider these factors, simple payback is an imperfect evaluation instrument. However, it is ideal for the present analysis, because it is one of the few evaluations which are used both by

energy experts and by families. Our findings from comparing the two payback calculations apply equally to most other economic evaluation methods (15).

Families who made major efficiency investments were more likely to explicitly compute payback. The majority made less explicit statements about whether energy changes "helped with the bill." All those who computed payback measured energy use by dollars billed. We give some examples of folk payback calculations, and then quantify the relationship between the folk and expert methods.

The families most frequently reporting payback were those who recently invested in wood heating equipment. If they had a free source of wood, the payback period was short and easily computed. Even those who spent over $1000 to buy an air-tight stove and wood harvesting equipment frequently reported payback in one or two years. Not surprisingly, most of these families had previously heated with oil or electricity, which in Michigan could cost over $1000 for the 1980 heating season alone. When paybacks are as short as these, the folk payback method yields a good approximation to the energy expert's method.

For longer paybacks, the folk method lengthens the computed time to payback, because it does not adjust for escalating prices. We found several cases of this; here we quote from one family which seemed especially thorough in their computations. Perhaps because of their occupations--the husband was a systems analyst and the wife had been a bank clerk--they recorded utility bills in a notebook and tried to calculate "how short a time we could get the insulation to pay for itself." Although they acknowledge they should compute from energy units, they in fact use the folk method, based on dollars. They say "It's hard for us to figure

the difference between what we would have used compared to what we did "use." They felt that the insulation had not paid for itself, and cited other benefits, such as comfort and home resale value, to justify their purchase (16).

They showed us their written records from which the payback calculations had been done. For one year before the insulation and one year after the insulation they recorded only the billed cost, and summed it for each 12 month period. No record was kept of consumption. After those first two years, they began to record the consumption also. But consumption was in smaller lettering, and was not summed into yearly totals (in both respects this family's records resembled those of Figure 1). Their heating costs decreased only seven percent the year after they had insulated and increased slightly above the pre-insulation costs the following year. Pointing to these figures, the husband told us "Look how discouraging that is, the next winter they stayed the same." Although his earlier remarks acknowledged that the folk method is a simplification, he still uses it to evaluate his investment. As predicted by Equations 2' and 3, his payback calculation fails to adjust for fuel price increases, and undervalues his financial savings.

Despite motivation and knowledge, this family calculated payback from dollar measurements, because it was easier. This case leads us to predict that even if information programs made consumers aware of the energy expert's method for computing payback, most consumers would continue to use the folk method.

How do we explain folk methods which work against the goals of their users? The family quoted above used methods which were inaccurate, but general-purpose and simplified. We believe this is an example of bounded rationality, as discussd by Simon (17). Simon shows that people apply

already-known methods in new problem solving situations, even if the known methods are not optimum for the new problem. Simon argues that this is often a reasonable strategy, since it avoids the effort of thinking through the new methods. Other investigators, such as Quinn and Lave, similarly find that in day-to-day life, people use approximate but easy methods rather than precise arithmetic calculations (18).

Comparison of the Two Payback Models

Why should we be concerned about folk payback calculations? By the time payback is calculated, the energy improvement has already been made. The literature on diffusion of innovations demonstrates that past actions are evaluated to form a basis for planning future actions, and for recommending these actions to others (19). We expect that a family who concludes that its energy changes have been ineffective, as did the example cited above, will be less likely to recommend the same actions to neighbors or to take further energy actions themselves. This significance warrants a quantitative comparison of the folk and expert methods.

The simplest folk payback method divides the investment cost by the first period's savings. The payback is n years, where n is computed:

$$n = \frac{I}{S_1'} \qquad (4)$$

For example, if an energy investment was $400, and the following heating season yielded bills $100 lower, the folk model would call this a four-year payback. Other related folk methods are possible; we will analyze the method of Equation 4 because it seems the most likely to be used, and because it yields results intermediate among others we have identified. All these folk methods are easy to use and employ folk units, but they share a common flaw--failure to adjust for fuel price escalation. This

failure increases computed payback time for two reasons: It reduces computed first year savings, and neglects to increase future benefits proportionally with higher future prices (15).

The above folk model will be compared with an expert model which is parallel, but which does adjust for fuel price increases. Combination of the earlier expert formulas, Equations 1 and 3, shows that payback is achieved after n periods, when:

$$I = (E_0 - E_1)(P_1 + P_2 + \ldots + P_n) \qquad (5)$$

To simplify the series of terms for price, we assume steady price increases of f, so that $P_1 = P_0(1+f)$, or generally for any year y, $P_y = P_0(1+f)^y$. Equation 5 can now be solved for n, since the right side can be expressed as a geometric series. Two further conventions simplify the solution. The investment will be expressed not in dollars, but as a proportion of the pre-improvement energy cost, written i (thus $i = I/C_0$). The ratio of energy used after the improvement to energy used before, E_1/E_0, will be written with the single symbol r. Thus the expert payback model can be written:

$$n = \frac{\ln\left[1 + \frac{f\,i}{(1+f)(1-r)}\right]}{\ln(1+f)} \qquad (6)$$

The folk model of Equation 4 can be expressed in comparable terms:

$$n = \frac{i}{1-(1+f)r} \qquad (7)$$

where

n is payback period

i is investment as a proportion of fuel cost, I/C_0

f is fuel price escalation

r is energy change ratio E_1/E_0

Note that we use Equation 7 to evaluate the folk payback model, but consumers would actually use the simpler Equation 4.

Equations 6 and 7 allow us to compare the two payback calculation methods under varying i, f, and r. Since we are thinking primarily of heating changes, evaluated seasonally, we will express n in years and f in change per year, although they can be in any consistent time units. The terms i and r are dimensionless.

Figure 2 illustrates the effect of fuel price escalation on payback period. Figure 2 assumes a 30 percent reduction in energy use (r= .7) and an investment equal to one year's pre-improvement fuel cost (that is, $I=C_0$, thus i=1). The folk and expert methods yield equal results if fuel prices remain constant, but as annual price rises exceed .15, the folk method makes payback appear to be more than twice the time of the expert method. In this and the following graphs, the upper line is the folk model and the lower is the expert model.

Figure 3 illustrates the effect of percentage energy reduction on payback. The investment is again assumd equal to one year's fuel cost (i=1), and the fuel price escalation is set at .15. On the abcissa, energy reduction is labelled as the more conventional "percent change" rather than r [percent change = 100 (1-r)]. Figure 3 shows that when energy reduction is large, the payback calculations yield approximately equal results, but when energy reduction is less than 40 percent or so, the folk method significantly overestimates payback period. In fact, small energy changes will never pay back under the folk payback model, since the curve is asymptotic to 23 percent (r=.87). The expert curve is asymptotic to 0.

Finally, figure 4 shows the effect of investment cost on payback (assuming f=.15, r =.7). When the investment is less than one-third of annual fuel cost, paybacks are quite fast, and the two models give

comparable results. Larger investments yield divergent paybacks. For example, assume that a home decisionmaker feels that an investment should pay for itself in five years. If a proposed improvement reduced energy consumption by 30 percent, under the folk model he or she would not invest more than a year's fuel cost, while under the expert model, investment of well over two years' fuel cost would be warranted.

In short, the two models yield similar results when fuel prices are nearly constant, or when investments are highly cost-effective (small cash outlays or large energy reductions). Highly cost-effective energy changes will be positively evaluated under either model. But there is a wide intermediate range of cost-effective measures for which the folk model predicts negative evaluation by the people who have adopted the measures. The reports from our interviews--the good paybacks on wood-burning equipment, the poor payback on the cited insulation example, and several less specific reports that various energy investments "didn't help much"--offer some empirical confirmation of the model. If fuel prices continue to escalate, we predict a continued negative bias in evaluations of cost-effective energy options. Even families who explicitly recited to us "you have to look at the amount, not just the dollars" nevertheless use the folk method. They use it because it is simple, it has worked well in the past, it uses familiar units of measurement, and it is compatable with other budgeting tasks.

Conclusions

Suspecting that our own technical energy background might cause us to perceive residential energy differently from most consumers, we utilized ethnographic techniques to interview people about their energy use. These interview techniques were originally developed for studying foreign

cultures; they help discover potential problems of interpretation due to differing assumptions made by the interviewer and the informant. In this technical area in our own culture, we also found differing assumptions.

Since consumers do not have the time or training to develop specialized energy measures, they utilize pre-existing folk measurements developed for other tasks such as household budgeting. The folk methods are sufficiently compelling in their cognitive simplicity that consumers choose them over expert methods even when knowledgeable of both. These methods, developed when unit prices were more stable and when energy was a smaller proportion of the family budget, are poorly adapted to current conditions.

To identify those appliances and activities which contributed most to the monthly bill, consumers used poorly-controlled experiments which combined many variables, or they relied on unconscious rankings based on perceptual or cognitive attributes. For example, lighting was consistently, but incorrectly, identified as a major energy user in the home. Consequently, families are wasting limited management resources on labor-intensive, but ineffective, conservation actions. When consumers made explicit measurements, they used units which were easily visualized and multi-purpose. They readily used gallons and dollars, but not kilowatt-hours, Ccfs, or joules.

Evaluations of efficiency investments are affected by dollar measures of energy. To compare folk methods, which do not adjust for escalating prices, with expert methods which do, we constructed models of payback as computed by each method. For highly cost-effective energy investments, the expert and folk models yield similar results, both evaluating the investment positively. However, for a wide range of intermediate cost-effective

investments, the folk method greatly underestimates economic attractiveness of the investment.

Folk techniques make possible measurement which would otherwise not be done, since the expert's techniques require unfamiliar units, complex computations, and (for payback) knowledge of future prices. Their use may be a reasonable choice for an individual; folk methods approximate with minimal effort to collect and process information. However, they lead to energy choices which are optimum neither for the family budget nor for national goals.

References and Notes

1. In 1968, 34 percent of U.S. energy was consumed directly by individuals, including home energy use and automobile fuel; from p. 8 in D. K. Newman and D. Day, The American Energy Consumer (Ballinger, Cambridge, Mass, 1975).

2. For description of ethnographic methods, see M. Agar, The Professional Stranger (Academic Press, New York, 1980) and J. Spradley, The Ethnographic Interview (Holt, Rinehart and Winston, New York, 1979).

3. For our study, "family" was defined as a co-resident group including at least one adult and having a personal commitment to each other. In interviews, we tried to include all adults, and included children when possible.

4. Average U.S. residential lighting is 335 net kwh annually, less than one-seventh of water heating at 2450 kwh. With total net residential use at 14855, lighting is only two percent of that total. If these proportions were calculated on primary energy consumption (gross rather than net), lighting would be slightly larger because most water heating is done more efficiently with natural gas. Data from Table 6, page 1005 in L. Schipper and A. J. Lichtenberg, Science V.194 #4269, 1001 (1976).

5. Probability sample of 400 Michigan families in 1978. C. K. Harris, J. G. Keith, and M. S. Wilhelm, Evaluation of Pilot Project Conserve in Michigan, submitted to the Michigan Energy Administration by the Institute for Family and Child Study, December 1980. Data from Table 2.12, page 2-23, augmented with data from personal communication. Poor energy knowledge is reported in several other surveys, summarized in R. J. Burby and M. E. Marsden, Eds., Energy and Housing (Oelgeschlager, Gunn

and Hain, Cambridge, Mass. 1980), pp 42-44.

6. From page 17 of B. M. Morrison, J. G. Keith, and J. J. Zuiches, Impacts on Household Energy Consumption: An Empirical Study of Michigan Families. In Sociopolitical Effects of Energy Use and Policy, CONAES supporting paper (National Academy of Sciences, Washington, D.C., 1979).

7. J. Wright, A. Meier, and M. Maulhardt, 1979, Energy conservation measures before you insulate your walls. Manuscript, 13 pp, Energy Efficient Buildings Program, Lawrence Berkeley Lab., Berkeley, CA.

8. Theoretical interest in prototypes derives from B. Berlin and P. Kay, Basic Color Terms (U. of California Press, Berkeley, 1969), and E. Heider, J. Exp. Psychol. 93, 10 (1972). Recent literature on prototypes is reviewed in C. P. Mervis and E. H. Rosch, Ann. Rev. Psychol. 32, 89 (1981), and in W. Kempton, The Folk Classification of Ceramics: A Study of Cognitive Prototypes (Academic Press, New York, 1981). Lighting's prototypicality is partly explained by lighting and electricity sharing important features (silent, "hot," moving by internal forces), by lighting's high perceptual salience within the contrast set, and by it being controlled consciously and often.

9. Education may eventually change the overemphasis on lighting, but the current prototypicality of lighting has been impeding this change. Impediments occur not only in public acceptance of information, but also in program design. For example, many energy conservation programs have used a light bulb as a symbol or have used slogans like "Turn out that light!" The prototypicality of lighting makes it a good symbol, likely to be chosen by advertising staff not acquainted with energy measurements. This has perpetuated the overemphasis on lighting.

10. The monthly 70 cent estimate is based on Shipper and Lichtenberg's 335

kwh annually (note 4) at the current national average rate of 5 cents/kwh. Note that this argument does not apply to lighting in the commercial and industrial sectors, where potential savings are large.

11. Hot water improvements are estimated to provide annual savings of 2606 kwh or 144 therms (estimates from note 7), which we price at 5 cents/kwh and 40 cents/therm.

12. This analysis is being developed further in research by W. M. Kempton, C. K. Harris, J. G. Keith, and J. S. Weihl.

13. Cooking is .63 quad annual 1973 U.S. resource consumption, of 14.07 quad residential total. A. B. Lovins, Soft Energy Paths (Ballinger, Cambridge, 1977), page 80, Table 4-4.

14. M. Murtaugh, K. Faust, and O. de la Rocha, Everyday Problem Solving Events. Paper presented at the American Anthropological Association Annual Meetings, Washington, D.C., 1980, manuscript 12 pp, Adult Math Skills Project, U. C. Irvine.

15. One could argue that the expert and folk models yeild more similar results than we calculate, since experts would discount future benefits, while the folk model does not. Thus, this argument runs, expert discounting would counterbalance expert adjustment for fuel price escalation. We discard this argument on two grounds. First, simple payback by definition does not discount; discounting is approximated by specifying a low criterion for required years-to-payback. Second, there is no evidence that consumers do not discount future benefits. Indeed, study of energy factors in consumer purchase of air-conditioners suggests that consumers use rather high discount rates, J. A. Hausman, Bell J. Econ. 10, 99 (1979).

16. This payback case is discussed in more detail in W.M. Kempton, P. M.

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18. N. Quinn, Am. Ethnol. 5, 206 (1978). J. Lave, A Model of mundane arithmetic problem-solving, (1979), manuscript, 15 pages, available from author at U. C. Irvine.

19. J. M. Darley and J. R. Beniger, J. Social Issues, 37, 150 (1981); E. Rogers and F. Shoemaker, Communication of Innovations: A Cross-Cultural Approach (Free Press, New York, 1971), and chapters 10 and 11 in R. H. Socolow, Ed., Saving Energy in the Home: Princetou's Experiments at Twin Rivers (Ballinger, Cambridge, Mass., 1978).

20. This study is part of ongoing research by the Family Energy Project, at the Institute for Family and Child Study, College of Human Ecology. We are funded by the Michigan State University Agricultural Experiment Station, as Project 3152. We are grateful for support and assistance from other members of the interdisciplinary research team: R. P. Boger, F. D. Case, P. M. Gladhart, C. K. Harris, D. R. Keefe, J. G. Keith, B. M. Morrison, B. D. Neff, and L. Nelson. We especially acknowledge Harris for his extensive comments and suggestions. Also, D. S. Dwyer, A. V. Millard, and S. M. Rennie constructively criticized this paper, and B. Schlagel, K. Warsco and M. Wojno helped conduct interviews.

	1976	1977	1978
Consumption (Ccfs)	1571	1501	1529
Cost (dollars)	360.76	379.66	389.73

Table 1. Our annual summations from the record excerpted in Figure 1. Some dollar totals are slightly different from those of Figure 1 due to correction of arithmetic errors. Note that between 1976 and 1977 consumption declined 10 percent, but this fact is obscured by the dollar summations.

Conservation action	Percent mentioning (N = 400)	Folk estimate of annual savings	
		Dollars	N
Reduce lighting	59	67	63
Lower thermostat	58	86	48
Insulate	27	133	26
Use less hot water	12	32	7

Table 2. Energy conservation actions suggested most frequently in an open-ended question. Half of the sample was asked to estimate annual dollar savings of the actions they volunteered; dollar figures average the estimates of those who responded. In contrast to the above folk estimates, energy analysts would rank lighting far below hot water in potential dollar savings. Data are from reference 5.

	Units Used 1976	1977	1978
Jan.	36.07	56.48	40.84
	184 11/13-9/15	247 11/13-9/14	174 11/11-1/14
Feb.	39.90	68.63	50.19
	205 9/15-11/14	293 1/14-4/14	224 9/14-11/14
Mar.	280 57.44	62.20	(est) 61.79
	11/14-3/13	273 11/14-3/14	263 11/14-3/14
Dec.	35.33	25.84	30.94
	160 10/12-11/12	101 10/12-11/11	115 10/24-11/22
total	300	31.64/each	31.63/each
	360.72	379.66	379.56

Figure 1. Excerpt from a family energy record. Dollars, Ccfs, and meter read dates are recorded. At the bottom of each column is the summation of annual dollars, and the monthly dollar average. Ccfs were not summed.

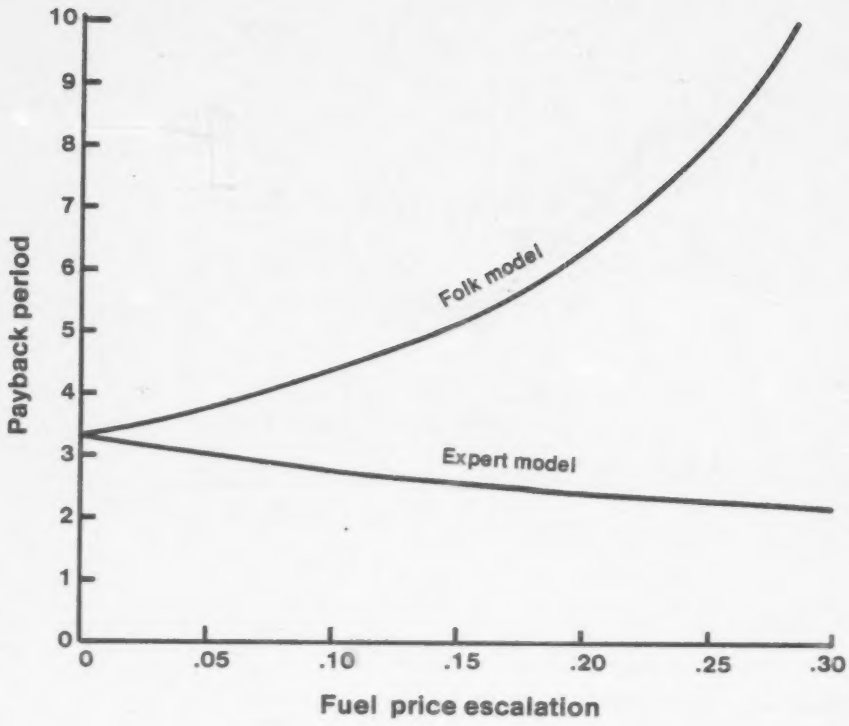

Figure 2. Payback period as a function of fuel price escalation, as computed by the folk model and the expert model. The curves are derived from Equations 6 and 7. Both curves assume an investment equal to one year's fuel cost, and a 30 percent decrease in energy use due to the investment.

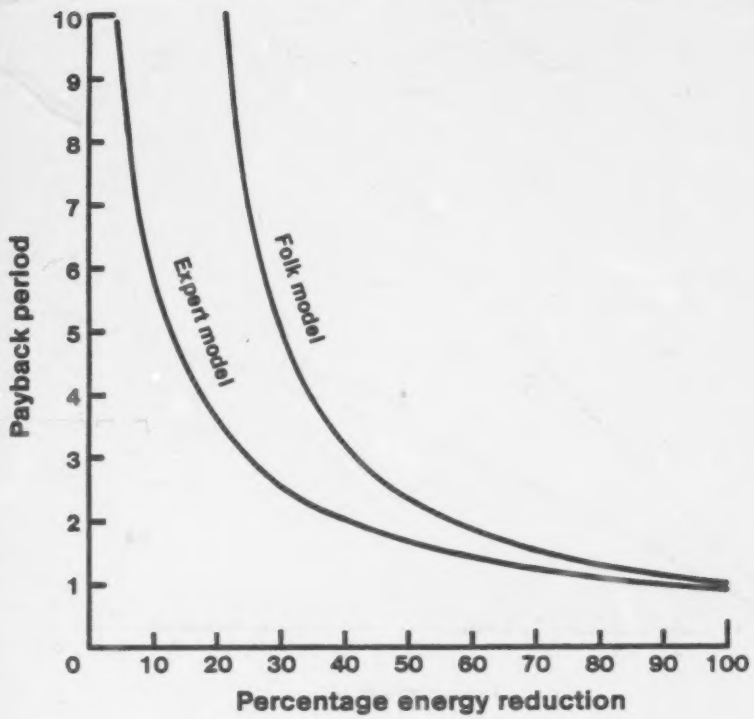

Figure 3. Payback period as a function of energy reduction, computed by the folk and expert models. Both curves assume annual fuel price increases of .15 and an investment equal to one year's fuel cost.

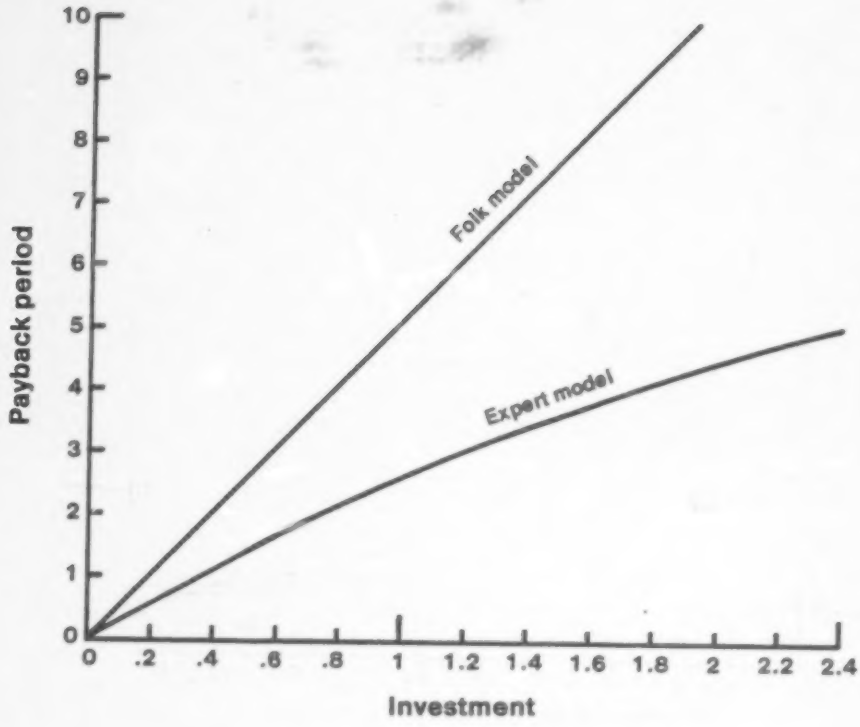

Figure 4. Payback period as a function of investment (investment is expressed as a proportion of annual fuel cost), computed by folk and expert models. Both curves assume annual fuel price escalation of .15 and a 30 percent decrease in energy use due to the investment.

HOME INSULATION: THE USER'S VIEW*

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ABSTRACT

Residential insulation in Michigan is studied from the user's point of view. From surveys and from open-ended ethnographic interviews, we analyze who is adding insulation, how they decided to do so, and what financial savings they expected. We also test the accuracy of family knowledge by asking about their own existing insulation, about their ranking of savings from various energy actions, and about their methods for computing savings of recently-installed insulation. We find a steady rate of retrofitting in Michigan, prompted by higher energy prices and by desire for greater comfort. However, we also find that insulation may not be installed, or may be installed in suboptimal quantities, due to families' overestimation of current insulation, or due to underestimation of economic savings. We find that families measure their energy consumption in dollars. Therefore, their calculated savings are underestimated because of failure to control for fuel price escalation. We conclude that more comprehensive, dwelling-specific, information services could greatly increase the efficiency of energy use in residences.

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HOME INSULATION: THE USER'S VIEW

INTRODUCTION

The findings reported here result from a variety of social science research projects beginning in 1973 and continuing through the present. Our interests are focused on the family and how its functioning is affected by, and affects, residential energy use. Thus we will not discuss materials, installation, or testing apparatus, but rather which families decide to install insulation, why they make this decision, and what they believe to be the results. In short, we will present the user's view of residential insulation.

Our interdisciplinary research group has conducted surveys in the Lansing area and throughout Michigan, from 1974 through 1980.[1] In addition, we have conducted open-ended interviews with a smaller number of families in 1980 and 1981. These interviews used ethnographic interviewing techniques to attempt to provide more complete in-depth information on a few cases, and to obtain information we did not think to ask for in the formal survey questionnaires. The survey data are presented as percentages and correlations, while the ethnographic data are presented as quotations in the families' own words.

Central Michigan, with its 7000 degree-day winters, design temperatures of -19°C (-3°F) [6], inefficient housing stock, and heavy reliance on fuel oil for residential heating, offers an excellent environment in which to study the residential view of insulation. The problems are vividly illustrated by the following quote from a family who, at the beginning of the 1973-74 oil embargo, was using over 5000 liters/year (1418 gallons/year) of fuel oil.

This family's first response was not insulation, it was drastic thermostat setback:

> We try not to set it ever above 65.[2] Before we had the kids, we never set it above 62. . . . We about froze . . . . I figured I'd do anything to keep the heat cost down, so: grab a blanket, and shake, and if you get too cold, you just sit on the heater for a while till you're burning, then you move aside (laugh) and the next person's turn. That's one good thing about floor heaters!

Clearly, the motivation to retrofit insulation is there, and our surveys find that people are indeed retrofitting insulation. The data in Table 1 show an increase in reported attic insulation over the year and four months immediately following the Iranian oil crisis: more families report having each level of insulation. Overall, ten to thirteen percent installed insulation between June 1979 and October 1980. Many did so themselves, depending on the difficulty of the job (71 percent installed their own attic insulation, 57 percent wall, and 89 percent basement or crawl space).

Still more people planned to install insulation in the future. However, data in Table 2 show that plans to install insulation are not a good predictor of whether insulation will actually be installed--less than a third of those who said they were planning to add insulation in the near future actually had done so over a year later.

Table 1--Change in reported attic insulation levels between 1979 and 1980, Michigan.

Amount of insulation	Percent reporting, June 1979 (N=1101)	Percent reporting, October 1980 (N=835)
At least 12.7 cm (5 in)	66.3	78.7
At least 17.8 cm (7 in)	32.4	44.3
More than 28 cm (11 in)	10.7	15.7

Source: Table 3, Reference [5].

Table 2--Percentage of households adding insulation between 1979 and 1980, according to their plans in 1979 (N=1185).

Plan to install?	Percent of families planning, June 1979	Did they actually install by October 1980? Percent Yes	Percent No
Yes	19.0	31.2	68.8
Probably will	8.1	16.7	83.3
Probably will not	4.2	16.0	84.0
No	64.1	18.6	81.4
Don't know	4.6	11.1	88.9

Source: Table 5, Reference [5].

Not all those installing insulation are using optimum amounts. A 1979 Michigan home audit program [4] found that 35 percent of 62,510 (self-selected) households reported installing insulation in the preceeding two to three years. This program judged R-22 a minimum amount of attic insulation and R-33 to R-49 to be optimum, depending on the climatic area of the state. Of those who had

added insulation, nine percent still lacked the minimum, while 64 percent still lacked the optimum.

Overall, these data leave us with two questions: 1) Can we trust self-reported insulation levels? and 2) Since families are installing insulation, why are they most frequently installing only minimal amounts? We need to know more about who is insulating and how they decide to do it.

SOCIAL VARIABLES

As social scientists, we expected to find that people's behavior would be related to the standard social and demographic variables: income, education, occupation, age and family composition. In the 1976 survey, we compared these variables with both possession of insulation and with plans to add insulation in the near future. Possession of insulation was weakly related to income (gamma =.23), but was not related to age, education, or occupation. Middle income households were slightly more likely to plan to add insulation in the future, compared with both upper income households, who did not plan to, and lower income households, who said they could not. But these differences were slight. Similarly, in the 1976 and 1977 surveys, neither income nor social status distinguished households who added insulation in the preceeding two years.

Altnough we found poor correlations with standard social variables, we found an either-or effect between different strategies. Some families felt in 1976 that for them, it would be very difficult to reduce their nighttime thermostat setting. These families were two to three times more likely than the others to report having added attic insulation in the 1977 interview. This and other evidence from the ethnographic interviews suggest that people

choose one strategy for dealing with higher heat bills; either they turn down the thermostat or they insulate. This choice may be related to different personality types, or to how handy they are about doing things around the house, or how much they know about the thermal characteristics of their house. Another possibility is that families try one first, and then the other.

Therefore, in order to understand who insulates and why, we address three further questions: 1) how much do people know about their home's thermal characteristics, 2) what benefits do they expect from insulation, and 3) how do they decide to insulate? As we will show, the third question is related to how they evaluate insulation after it is installed.

KNOWLEDGE OF INSULATION

We evaluate knowledge about energy in several ways. We are concerned with what people <u>believe</u> about energy, even if it is wrong, because their beliefs affect their decisions. Our assessment of their knowledge is based on questions in surveys, and on their descriptions of their reasoning in ethnographic interviews.

As a test of general energy knowledge, we asked families "What things do you know that a family could do to reduce the energy consumption in their house?" Only three measures were suggested by more than 15 percent of the interviewees. As shown in Table 3, thermostat and lighting reductions were mentioned far more often than insulation. A sample of those mentioning each measure was asked: "For each of the things mentioned, please give me a rough idea of how much each thing would save you in energy cost per year." Average estimated savings, also shown in Table 3, were too high for lighting and too low for insulation. We analyze these findings in more detail

elsewhere [3], [5], [7], the present relevance is that family misperceptions about the relative consumption of various household devices will tend to cause less insulation to be installed than would otherwise be the case.

Table 3--Energy saving measures suggested by Michigan families, with family estimates of dollar savings. Survey conducted in 1978.

Suggested measure	Percent suggesting (N=1000)	Average estimated annual savings (N)
Lower thermostat	59.1	$ 78 (136)
Reduce lights	57.7	50 (100)
Insulate	32.7	114 (65)

Source: Table 2.12, Reference [3].

A test of more specific knowledge involves existing insulation in families' own homes. We asked about wall insulation because it is more difficult to see than attic or crawl space insulation. In the 1976 survey, 63 percent reported having wall insulation, and in the 1979 survey, 75 percent reported it. In light of the age of the housing (68 percent of owner-occupied homes in Michigan were constructed before 1960 [8], we considered these family estimates unrealistically high. A subsequent survey asked how people knew whether they had wall insulation. Forty percent gave some source of information, as tabulated in Table 4. Almost 60 percent admitted that they had not checked. Thus, while 75 percent say they have wall insulation, only 40 percent have any way of knowing whether they do or not. In other words, when they lack information, people overwhelmingly assume that their houses are insulated.

Table 4--Reported method for determining presence of wall insulation (N=1256, 1980).

Method of checking	Percent who checked	
Built house, or had insulation installed	10.9	
Had contractor or other person check	12.0	
Looked behind baseboard	3.6	
Put hand on wall	0.3	
Took electric outlet cover off	4.8	
Other	9.1	
Total (did anything to check)		40.7
Did nothing	59.2	
(Left question blank)	0.1	

Source: Reference [5].

We present two cases from our ethnographic interviews to complement the above survey data and suggest how peoples' overestimates of wall insulation develop. We pick cases of families who we would expect to know--both heads of household hold graduate degrees in technical fields and both describe themselves as "interested in energy."

The first case is an engineer who built his house in the 1950s, and told us in 1980 that he had "3½ inch" wall insulation; he elaborated by saying that it was "a full thickness blanket." Our inspection of the insulation revealed a 3.8 cm (1½ inch) fiberglass. We infer that his memory process worked as follows: During construction, he knew that he was putting in the recommended amount of insulation. He remembered that he had put in "enough" rather than remembering the numerical measurement. When attention to insulation grew after the oil embargo, 8.9 cm ("3½ inch") was recommended (the maximum which

fits in a standard-size wall). Since our informant remembered he had put in the recommended amount, he concluded that it must be "3½ inch." We compare this with his attic insulation, which he saw was inadequate, and brought up to 15 cm (6 inches):

> I thought that I was putting a fair amount [of insulation] in the ceiling at that time [when built], but it turned out to be not near as much as I'd add later on, years later . . .

While acknowledging changing standards for the attic, he was unable to easily inspect the walls, and assumed they were adequately insulated.

The second case is a research scientist who strived to reduce energy consumption through careful lighting and thermostat scheduling. She had purchased her house from a contractor who built it for himself in the late 1950s, and she had found it to be well-built and structurally sound. She had not checked to see how much insulation was in the house, but reasoned that since the contractor had built it for himself, he would have insulated it properly.

In both cases, these people are well aware of rising energy prices, but they have not connected price changes with changing recommendations and standards for insulation.

NONFINANCIAL INCENTIVES

Fuel cost is an important factor motivating installation of insulation, but it usually is not the only factor. Our ethnographic interviews provide examples of diverse sources of inspiration to install insulation. The most common, of course, is the higher cost of fuel. Promotion by insulation companies is sometimes cited, as well. But other factors often tip off the

family that their insulation is inadequate: feeling a stream of hot air when inspecting the attic in winter, noticing water droplets condensed on the inside of an exterior wall, noticing large temperature differences among different rooms of the house, or hearing from neighbors about reductions in heating bills after insulating.

All of these realizations emphasize the "seeing is believing" aspect of decisions to innovate, and the importance of talking to friends about it (see also references [9, 10] for the importance of personal communication). For example, the research scientist mentioned above assumed that her house was adequately insulated when we interviewed her in 1980. When we returned a year later for a second interview, we found that her entire house had been insulated and asked why she had changed her mind. She reported that a friend had purchased a new house which was designed to be "energy efficient," and the friend's heating bills for the previous winter were much lower than our informant thought possible. Only then did she realize how much possibility for improvement there was in her own house.

EVALUATION OF INSULATION

When varying degrees of precision, families usually evaluate insulation after they have installed it. This evaluation is an important factor in future decisions to add further insulation, and in friends and neighbors' decisions to insulate. First we discuss comfort factors, then we analyze in detail payback calculations.

In insulating older Michigan houses, after financial savings, the most important effect is uniformity of temperature throughout the living space. This was expressed most clearly by a man who explained why he insulated and replaced all his windows:

Informant: Cause everybody was noticing how cold and drafty it was! So we did it. Now everybody's happy again. Everybody's room is warm and so on, yeah.

Interviewer: If they were cold, they could of just turned the thermostat up more, couldn't they?

Informant: Oh, they could of, but you can't--some rooms would be worse than others depending on which way the wind comes from, so you can't off-balance that.

Many people reported this effect less clearly than the above. A common observation was that after insulation, "we could set the thermostat lower." From indirect evidence, we infer that some of these people think of the thermostat as a flow regulator, rather than a negative feedback device. Without recognizing that uniform temperatures increase comfort, they assume that they are reducing the heat flow to compensate for the reduced heating load. One couple explained that their heat bills were lower now with the insulation <u>because</u> they were able to turn down the thermostat.

We now turn to family calculations of savings from insulation. In the ethnographic interviews, we found that several families tried to calculate the economic return on their insulation investment. Some of these people were careful record-keepers, and had recorded their utility bills over the past several years. Unfortunately, they usually would record only the dollar amounts. Even those who recorded fuel quantities would use only the dollar quantities in their yearly summations. More commonly, they would not keep written records at all, but would make statements from memory such as:

. . . this year we didn't have any $100 gas bills, did we?

I mean we used to have $100 gas bills.

Dollars are used rather than fuel units because they are understandable quantities, they are easy to remember, they can be used to compare fuel with other commodities, and because dollar measurements are made anyway, for family budgeting.

However, when families tried to calculate the economic return on their insulation investments, their dollar measurements caused inaccuracies by failing to adjust for escalation in fuel cost. These calculations were most commonly done informally, such as saying that the insulation "didn't help with the bills." A few families explicitly stepped through their payback calculations with us, providing detailed examples of what seems typical of payback calculations of most of the families we interviewed. Below we compare the payback calculation used by energy analysts, with the methods we find families actually using. (We draw the following evidence from a more detailed discussion in reference [7]).

An analyst would measure energy units, so that the effect of insulation would appear as in Figure 1. Figure 1 assumes that insulation, installed between year 0 and year 1, decreases energy use by 30 percent. The analyst would compute financial savings by multiplying the saved fuel in each year by the cost of fuel for that year. The same insulation retrofit is evaluated in Figure 2, with the bars representing cost rather than energy units. We again assume a 30 percent energy decrease; we also assume 15 percent annual fuel price increases. In Figure 2 the hollow bars represent the financial savings as computed by the energy analyst, while the solid bars represent the actual amounts paid each year. (An analyst would discount future benefits to their present value; we ignore this since we are primarily comparing first-year savings.)

The point we want to make is that very few families compute savings as shown in Figure 1 and the hollow bars of Figure 2. Families are not measuring fuel units, they are measuring what they are actually paying--the solid bars of Figure 2. Thus, families measure savings as previous cost minus current cost. This family measure of savings is represented in Figure 2 by the dotted line, showing the distance between the top of the solid bar of year 0 and the top of the solid bar of year 1. In this hypothetical example, 30 percent savings and 15 percent fuel price escalation, the family method of measuring costs causes the family to underestimate first-year savings by almost half.

Below, we briefly compare the two methods algebraically. For year y, we write cost as C_y, energy consumed as E_y, and price per unit as P_y. Cost for any year is energy units times price per unit, or $C_y=E_yP_y$. For an efficiency improvement made between years 0 and 1, the savings in year 1, S_1, is computed:

energy expert method	$S_1=P_1\ (E_0-E_1)$
family method	$S_1=C_0-C_1$

The family method is easier primarily because it uses a well-known measurement unit--dollars. It requires only a single arithmetic operation. Further, it is consistent with household money management, which is based on comparing and anticipating expenses repeated in regular billing cycles [11]. But when fuel prices escalate, this family method underestimates dollar savings; thus it makes insulation investments appear less attractive.

We found several cases of this computing savings by dollar changes. As an example, we quote here from one family which seemed especially thorough in their computations. Perhaps because of their occupations--the husband was a

systems analyst and the wife had been a bank clerk--they recorded utility bills in a notebook and understood payback calculations. Although they acknowledge they should compute from energy units, they in fact use dollars. Since their computation method shows a poor payback, they cite other benefits to justify their purchase:

> Wife: We were trying to see, you know, like how short a time we could get the insulation to pay for itself and stuff, and you can't really look at it like that. Not anymore anyway because the rates still keep going up and up.
>
> Husband: Yeah
>
> Wife: It's just [the] comfort factor I guess.
>
> . . .
>
> Husband: It's hard for us to figure the difference between what we would have used compared to what we did use.
>
> Interviewer: Um-hmm. Because everything was changed?
>
> Husband: Well, the prices are going up, you know, and the fact that you have no control over . . . the weather aspect, you know.
>
> Wife: Yeh, the one winter is colder than another.
>
> Husband: It's the kind of thing where we could probably sell the house; that's a selling point on the house is that it's insulated. It's more comfortable just to be here. We felt whatever we did save, we would be saving <u>something</u>, you know, consumption wise, even though the prices were going up. We didn't bother to sit there and figure it out.

They showed us their written records from which the payback calculations had been done. For one year before the insulation and one year after the insulation they recorded only the billed cost, and summed it for each 12 month period. Fuel units were not summed. Their gas costs decreased only seven percent the year after they had insulated and increased slightly the following year. Pointing to these figures, the husband told us: "Look how discouraging that is, the next winter they stayed the same." Although he recognizes that their method is an improper simplification, he still uses it to evaluate his investment.

In sum, this family distinguishes price, dollars billed, and consumption in energy units, more clearly than the average family. They are aware of how an energy expert would compute financial savings, and they do compute financial savings themselves. Nevertheless, their recordkeeping and their computation were based on easy-to-understand units and calculations, which did not provide the information they wanted. Despite motivation and knowledge, they measured energy savings in dollars, because it was easier. This case leads us to predict that even if information programs made consumers aware of the energy expert's method for computing savings, most consumers would continue to use their present methods because they are computationally easier.

These data suggest the need for a retrospective energy evaluation service. Such a service would measure energy savings realized after an improvement (such as insulation) has been made. It would then translate energy savings to dollar savings and provide this information to consumers.

CONCLUSIONS

This paper has examined Michigan families' view of residential insulation, There is strong motivation to retrofit insulation for reasons of fuel cost and

comfort, and many Michigan families are doing so. However, many factors reduce the number of families who do decide to insulate, and reduce the amount of insulation they install.

When asked for energy-saving ideas, families mention lighting and thermostat setting much more often than insulation, and when asked to estimate dollar savings, they underestimate insulation savings with respect to the other two. In the absence of information about their own homes, people overestimate the amount of insulation they already have and are thus less inclined to add more.

Families use dollars, not energy units, to measure the amount of energy they consume. When they evaluate recently-installed insulation, they compare fuel bills before and after, underestimating savings by that year's fuel price escalation. Since decisions to install insulation are heavily influenced by the previous experience of the family and of their neighbors, undervaluing of savings of recently-installed insulation will reduce future adoption of insulation.

Many of these problems--assessment of present insulation in house, projection of expected savings, and accurate measurement of savings after installation--could be solved through professional services in the home. In many parts of the country, the utility-run Residential Conservation Service now provides partial assessment of existing insulation and projection of savings. The proposed Princeton "house doctor" is similar but provides more comprehensive assessment [12]. We know of no programs which calculate savings for the family after insulation has been installed. Existing institutions, such as cooperative extension, utilities, and insulation installers, could and should provide more comprehensive assessment and evaluation services.

ACKNOWLEDGEMENTS

This paper reports findings from two interdisciplinary research efforts of the Institute for Family and Child Study at Michigan State University. We wish to acknowledge the contributions of our colleagues on the Family Energy Project, R. P. Boger, F. D. Case, C. K. Harris, J. G. Keith, B. M. Morrison and J. J. Zuiches; and acknowledge financial support of the Michigan Agricultural Experiment Station through Project 3152. We wish to thank C. K. Harris and J. G. Keith, co-directors of Statewide Michigan Project Conserve for assistance in preparation of the paper and permission to publish their results.

FOOTNOTES

1. The data presented here are derived from a series of surveys conducted by the authors and their associates between June 1974 and October 1980. The Family Energy Project interviewed an area probability sample of 216 families from the Lansing, Michigan SMSA in 1974. Using the same sampling frame 263 families from the Lansing SMSA were interviewed in 1976, including 127 of those responding in 1974. These samples constitute the 1976 or 1974 data we describe here; detailed sampling procedures are presented in [1]. Following an experimental program of infrared heat loss analysis provided to 256 of these families, they were interviewed in October 1977 by telephone [2]. Michigan Project Conserve, a residential energy audit program was conducted on a pilot basis in fifteen counties in mid-Michigan in 1977-1978 and on a statewide basis from November 1978 through August 1980 by the Institute for Family and Child Study under contract to the Michigan Energy Administration [3,4,5]. To evaluate the effects of the pilot program, 1000 households were interviewed in April 1978 and June 1979 [3]. The April survey was the source of the data referred to in the text as the 1978 survey. Telephone interviews with a probability sample of 2016 households representing the State of Michigan were conducted in June 1979 to evaluate the effects of the Statewide Conserve program and 1258 of these households were reinterviewed in October 1980. These surveys are referred to in the paper as the 1979 and 1980 surveys. Detailed sampling procedures are available in [5].
2. Following ASTM guidelines, we use SI units for our measurements. However, we do not try to convert units when our informants give them in quotations, we quote figures as we are given them.

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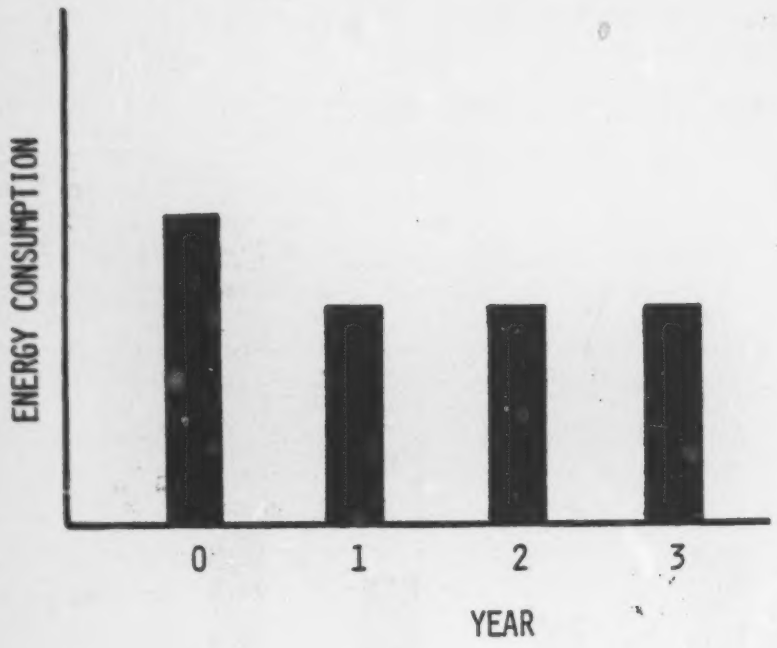
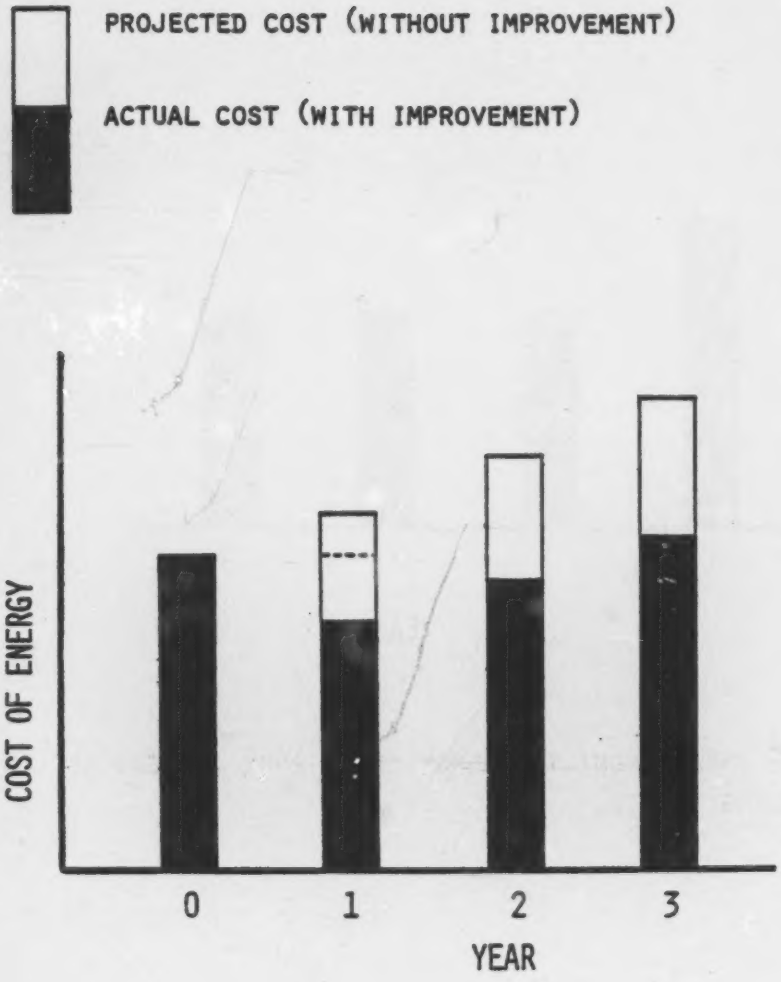


A 30% IMPROVEMENT IN ENERGY EFFICIENCY AS MEASURED IN ENERGY UNITS.

Figure 1



CHANGING ENERGY BILLS AS SEEN BY A FAMILY (SOLID BARS). GRAPH ASSUMES A 30% EFFICIENCY IMPROVEMENT AFTER YEAR 0, AND YEARLY 15% FUEL PRICE ESCALATION.

Figure 2

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March 10, 1982

Representative Don Fuqua, Chairman
House Committee on Science and Technology
Subcommittee on Energy Development and
Applications
Room B374
Rayburn House Office Building
Washington, D.C. 20515

Attention: Mr. Gene Frenckel

Dear Mr. Frenckel:

By this letter, I would like to request permission to submit for the record a Position Paper on the DOE Solar Thermal Program that has been recently prepared by the Solar Thermal Program Review Panel, which I chair. A copy of this paper is attached together with a current roster of the Panel. The purpose of the Panel is explained in the Background section of the paper.

This submission is in support of subcommittee hearings on the FY83 Budget Proposal for DOE's Solar RD&D Program to be held Tuesday, March 16, 1982.

In the event of any questions you may contact me at (913) 967-2554.

Very truly yours,

J. C. Grosskreutz
Chairman
Solar Thermal Program Review Panel

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Attachment

The Federal Solar Thermal Program
A Position Paper

Prepared by
The Solar Thermal Program Review Panel

February 1982

Executive Summary

The principal benefit to this nation of the solar thermal program is to increase the number of our energy producing options, thereby enhancing economic stability.

The program started in 1973 under National Science Foundation auspices as a high risk/high payoff research and development effort with this benefit in mind. In the intervening nine years the program has made significant progress toward reducing the technical and economic risks of the solar central receiver and line focus (trough) technologies, principally for production of electricity and industrial process heat (IPH). These technologies are nearly ready for transfer to the private sector for subsequent commercialization. The Panel feels strongly that the program is at a critical point in its development and that to wean it suddenly from the flow of well-spent Federal dollars of the past decade would be a serious mistake, especially when a strongly interested industrial and user constituency already exists. This rationale is one central theme of our position paper.

The other theme is that new, untried ideas and technology concepts for solar energy utilization have been and are currently being developed within the Federal solar thermal program. The Panel believes that these projects, which will be discussed, qualify now as high risk/high payoff R&D projects and merit investment of Federal research dollars.

The Panel is mindful of the need to drastically reduce the financial burden of the Federal government and the need to concentrate in areas of highest priority, greatest need, and greatest benefit to national energy problems. The membership has viewed solar energy in this context soberly and thoughtfully. Our position is that the Solar Thermal Program merits continued Federal investment, both for those elements that are close to the point of transfer to the private sector and those that are still in the high risk stage of development.

Why Solar Energy?

Solar energy has unique properties that make it an attractive resource. These properties are:

- Renewable
- Non-polluting

- Clean, high temperature heat (in excess of comparable conditions produced by coal or nuclear)
- Visible spectrum photons capable of driving quantum processes (e.g. photovoltaic cells, photochemical reactions)
- Stable energy production costs, once the capital investment for conversion has been made

In addition, significant reasons exist for development of solar thermal technology.

- Solar energy conversion processes can produce heat, electricity and transportable fuels and chemicals - all products to which our current society is structured and on which we are dependent.
- Solar energy can be used easily in a solar/fossil hybrid operating mode for a wide variety of fossil fuel displacement applications.
- Solar energy is an attractive, alternative fuel option for electric utilities in the sun belt where oil and gas is not an economic option.
- As a renewable, omnipresent resource it is not subject to interruption by others.

Why Federal Involvement?

The answer to this question is that despite great progress, there still exist sufficient technical and economic risks to prevent complete private sector investment in solar thermal energy. Operating experience sufficient to establish operation and maintenance costs are lacking for central receiver technology. Although costs have been reduced by factors of 2 or 3, another factor of 2-3 is required. This seems close enough for private investment, why isn't it happening?

The major reasons lie in the fact that a solar thermal plant for electricity, process heat or fuels production is a system, composed of many subsystems: solar collectors, solar receiver/boilers, thermal storage, heat exchangers, turbine generators, and a host of interconnecting piping, controls, wiring and buildings to contain it all. Consequently,

- There is no one industry or manufacturer that will take the risk of complete solar thermal systems R&D because no one industry will ever manufacture, test and market complete utility systems and hence profit from the entire system.
- For a group of industries to spread the development risk among themselves, they must be assured of a predictable market for their subsystems to be integrated into complete solar thermal electric systems.
- To generate the market required for individual company risk investment, the system users (e.g. utilities) must be convinced of system reliability and the O&M costs.
- If the market exists, manufacturers will work to get costs down to the point required for, say, competitive electricity production.

The critical step in this sequence is convincing the user of reliable operation and reasonable operating and maintenance costs. In other words, a pilot plant or demonstration plant is required. On the other hand, the capital cost of solar demonstration plants is too large at this time for private industry to undertake except on a cost sharing basis.

This Panel believes that the role of integrating solar systems research, development and test must fall primarily to the Federal government.

Recommended Structure of the Solar Thermal Program

The overall structure of the program is best perceived in terms of a near term component that is active through about 1986, and a long-term component geared toward the year 2000 and beyond.

The near term objective is to transfer to the private sector the technology that has achieved substantial technical and economic risk reduction through Federal support over the past nine years. Achieving this objective requires both a technology base Federal R&D support program and Federal/private cost-shared demonstration projects. These demonstration projects should properly be developed by strong user constituencies through Congressional initiatives.

The longer term objective is to conceive and develop advanced solar thermal systems, their subsystems and components, for the purpose of a substantial reduction of technical complexity and risk and the consequent cost reductions.

Program Emphasis

For the near term, emphasis should be on the following items

1) Measurement and evaluation of the major technical risks remaining in central receiver technology including evaluation of Barstow Pilot Plant operations for electric power production.
2) Design of solar-repowered utility generating stations sufficient to provide a basis for cost-shared repowering construction projects. (See Constituency Programs below.)
3) Conceptual design of lower cost heliostats for the central receiver system.
4) Completion of the cost-shared modular industrial solar retrofit (MISR) programs for trough collectors.
5) Operation of outdoor, real-scale and real-time solar research facilities to obtain central receiver and trough system operating and performance data.

[Note: Federal operation of these solar system research facilities for both near and long-term programs is essential for continued progress. Their relatively large scale is dictated by the inherent diffuseness of incident solar radiation. They are the minimum size needed for actual operation of experimental systems and subsystems at a meaningful level under real-time conditions.]

Constituency Projects

1) Solar Repowering

Because of recent budget constraints and policy decisions, Repowering has been eliminated by the Administration as unnecessary and not consistent with their policy filter. On the other hand, the Review Panel has consistently given this program a high priority as the last step in transferring the central receiver technology to the private sector.

2) Small Community Power Systems Experiment

A solicitation was issued in October, 1979 and six candidate sites were selected for a 1 MWe parabolic dish system. The Panel believes that either a site should be chosen during FY82 and a viable dish technology chosen for the experiment, or the whole project should be scrapped.

3) Crosbyton Hemispherical Bowl

A successful demonstration of the hemispherical bowl technology was achieved about one year ago. However, the Panel believes that this project should be terminated unless it can be demonstrated in FY82 that the performance and costs of energy are comparable to those expected from central receiver and parabolic dish technology.

For the longer term, beginning in 1982 and continuing throughout the following two decades, emphasis should be on the following items.

1) Advanced Systems for Production of Transportable Fuels and Chemicals.

2) Continued Development of Parabolic Dish Technology.

3) Development of Solar Pond Technology.

4) Long-term High Temperature Storage Technology.

5) Continued Low Cost Collector Development

6) Materials Research and Development in support of the above items.

Budget Recommendation

The Review Panel recommends that the solar thermal program receive a base budget of at least $50 M/year, not including the "constituency programs" discussed in the preceding section. Such a budget would allow orderly implementation and sustainment of the recommendations given in this position paper.

The Federal Solar Thermal Program
A Position Paper

Prepared by
The Solar Thermal Program Review Panel

February 1982

Background

The Solar Thermal Program Review Panel is an ad hoc panel created early in 1980 at the request of the Director, Solar Thermal Energy Systems, DOE. The Panel consists of a broad representation from universities, industry, private and public utilities, architect engineering firms and research institutions, both electric power and gas, who are knowledgeable in solar energy and it's applications. Members are selected by the chairman in consultation with the DOE Program Director.* The Panel's charter is to review the DOE Solar Thermal Program semiannually and to provide recommendations and counsel to the Director of that program. Panel members serve without remuneration.

During 1981 the DOE solar program experienced a transition from a large budget, multi-faceted program with strong Administration support to a constrained, possibly zero budget program with no Administration support and a strong policy filter for new initiatives. The Review Panel consequently found its role shifting from one of advice on program balance, program element management, strengths and weaknesses and new program opportunities to one of advice on survival strategy and what reasonable actions might be taken to maximize the substantial federal and private investment in the solar thermal program during the past eight years.

It is in the context of this recent activity that the Review Panel undertook the task of writing this position paper. The Panel feels that the subject matter is timely and in the national interest, and that the membership is well informed and can provide objective views and recommendations regarding the Federal solar thermal energy program.

*A roster of the current membership is attached to this paper.

The principal benefit to this nation of the solar thermal program is to increase the number of our energy producing options, thereby enhancing economic stability.

The program started in 1973 under National Science Foundation auspices as a high risk/high payoff research and development effort with this benefit in mind. Only a few people took it seriously at that time, and the utility industry in particular viewed it as an extremely high risk venture. In the intervening nine years the program has made significant and outstanding progress toward its initial goal of reducing the technical and economic risks of the solar central receiver and line focus technologies, principally for production of electricity and industrial process heat (IPH). In support of this claim, five large southwestern electric utilities recently submitted an open letter to the Administration, Congressmen and their staffs in which a strong position was taken relative to the advanced state of technical readiness of the central receiver system. In their words:

> "The solar thermal central receiver program, a program with ten years momentum, and hundreds of millions of dollars invested, is nearing the point of being passed from government to the private sector. Solar central receivers are large facilities which generate electric power, as well as power for industrial process heat and enhanced oil recovery. The facility consists of many mirrors (heliostats) that focus the sun on a central receiver tower to produce useful energy. Utilities consider this potentially an important source of power generation in the future, but cannot complete development without shared Federal assistance."

The essential point is well made here. What started as a high risk research program in 1973 has successfully matured under Federal sponsorship to the point where it is nearly ready for transfer to the private sector for subsequent commercialization. The Panel feels strongly that the program is at a critical point in its development and that to wean it suddenly from the

flow of well-spent Federal dollars of the past decade would be a serious mistake. And, in our opinion it would be a violation of the Administration's policy of supporting high risk projects to the point that the private sector is willing to assume the risk.

The fact that solar central receiver and line focus technology began as high risk/high payoff Federal R&D projects nine years ago should be fully recognized. These projects should not now be penalized for the simple fact that 90% of the race has been run successfully. Every successful R&D project reaches this hand-off stage sooner or later. To fail to see it through its adolescence to fruition is not good business, especially when a strongly interested industrial and user constituency already exists. This rationale is one central theme of our position paper.

The other theme is that new, untried ideas and technology concepts for solar energy utilization have been and are currently being developed within the Federal solar thermal program. The Panel believes that these projects, which will be discussed, qualify now as high risk/high payoff R&D projects and merit investment of Federal research dollars.

The Panel is mindful of the need to drastically reduce the financial burden of the Federal government and the need to concentrate in areas of highest priority, greatest need, and greatest benefit to national energy problems. The membership has viewed solar energy in this context soberly and thoughtfully. The Review Panel does not have a single member, nor has it had one, who could be classed as an activist or zealot, or motivated to achieve social change via solar energy. In point of fact, the solar thermal program has come under heavy attack from that constituency during the past five years, mainly because of the program's commitment to developing technology for the use of American industry, especially electric utilities. Therefore we ask that the remainder of this Position Paper be read as a serious recommendation by serious, qualified people.

Our position is that the Solar Thermal Program merits continued Federal investment, both for those elements that are close to the point of transfer to the private sector and those that are still in the high risk stage of development. The important questions are:

Why solar energy?

Why a need for continued Federal involvement?

With agreement on these issues, the remainder of the task becomes one of defining program focus and priorities. This position paper addresses both aspects of the problem.

Why Solar Energy?

Why is electricity, process heat and fuels production from solar energy an essential undertaking for the U.S. on a serious and sustained basis? The sun, our star, is the only source of energy available to us except for that trapped within the earth's crust as chemicals (not including stored fossil hydrocarbons), geothermal reservoirs and fissile or fusion materials. The free energy associated with chemicals normally requires additional energy (usually heat) to obtain its release; and, it is finite. Uranium and thorium reserves are also finite and have their associated waste problems when utilized as energy sources. The solar energy stored over eons as fossil fuels does not represent a long-term option for us. Thus we are faced eventually with either utilizing "real time" solar energy as it strikes the earth or with creating and containing the fusion energy source of our sun here on earth. Both options are worthy of research and development.

The attempt to create a controlled fusion reaction in the laboratory has been underway now for about 30 years, with net power production yet to be demonstrated. Serious solar energy R&D has only occurred during the past 8-9 years in the U.S., with significant results already achieved.

Solar energy has unique properties that make it an attractive resource. These properties are:

- Renewable

- Non-polluting
- Clean, high temperature heat (in excess of comparable conditions produced by coal or nuclear)
- Visible spectrum photons capable of driving quantum processes (e.g. photovoltaic cells, photochemical reactions)
- Stable energy production costs, once the capital investment for conversion has been made

The fact that it is non-polluting, -- as a source, during its conversion or as a result of the products of its conversion -- gives it significant advantages over the non-renewable alternatives, fossil and nuclear energy.

Significant reasons contributing to the rationale for solar development are:

- Solar energy conversion processes can produce heat, electricity and transportable fuels and chemicals - all products to which our current society is structured and on which we are dependent. Hence, solar energy is compatible with current technology.
- Solar energy can be used easily in a solar/fossil hybrid operating mode for a wide variety of fuel displacement applications.
- Solar energy is an attractive, alternative fuel option for electric utilities in the sun belt where oil and gas is not an economic option. Solar thermal electric plants offer advantages of modularity in ~ 100 MWe sizes, and short (~ 5 year) construction times compared to nuclear and coal, with resulting lower total costs of money.
- As a renewable, omnipresent resource it is not subject to interruption by others.
- Use of solar energy reduces the depletion rate of non-renewable resources.

Because solar energy is (fortunately for us) diffuse in nature, land requirements are large for significant fuel displacement. Furthermore, the sun shines only during the day and is subject to interruption by clouds, two characteristics that make it difficult to match directly to load demand on a 24-hour basis.

But in fact, it has been shown[1] that total land requirements for coal-fired and solar thermal electric generating plants are on close parity, i.e. about the same when all the land use for siting, ash and sludge disposal, railroad right-of-way, mines, limestone resources, and transmission lines is considered.

Furthermore, technically feasible means of storing solar thermal energy for 3-10 hours have been designed and are being experimentally verified under DOE contract, and cost effective methods for storing energy for several hundred hours appear feasible. Such storage is sufficient to match daily load demand curves in summer peaking utilities so that stand-alone solar thermal electric plants are feasible. Thus, a strong case can be made for conception and development of solar thermal energy conversion technologies.

A review of the record of the past nine years shows that substantial technical progress has been made on first generation systems for electricity and industrial process heat generation utilizing central receivers (CR) and line focus (trough) technologies.

Why Federal Involvement?

Given this substantial progress, why should there be a continuing Federal role?

With rapidly escalating fossil fuel prices and societal pressures essentially shutting down the nuclear industry, why can't or why doesn't the private sector step in and exploit this attractive option? The answer to this question is that despite great progress, there still exist sufficient technical and economic risks to prevent attracting complete private sector investment. Operating experience sufficient to establish operation and maintenance costs are lacking for CR technology. Although CR and trough system costs have been reduced by factors of 2 or 3, another factor of 2-3 is required.

[1] Solar Energy & Coal: "A Comparison of Land Use Requirements", M. J. Pasqualette and B. A. Miller, Arizona State University, 1980, for the Arizona Solar Energy Commission.

A combination of clever design, lightweight, durable materials, and mass production will be needed to produce this last factor. This seems close enough for private investment, why isn't it happening?

Some historical perspective is instructive. The risk-taking entrepreneur in most new technologies has been the hardware manufacturer who stood to recapture his venture capital with significant gain. Examples are television sets, integrated circuits, computers, etc. In each of these a consumer product can be clearly identified, manufactured and marketed. In contrast, a solar thermal electric utility plant is a system composed of many subsystems: solar collectors, solar receiver/boilers, thermal storage, heat exchangers, turbine generators, and a host of interconnecting piping, controls, wiring and buildings to contain it all. No one company manufactures, tests and markets all of these subsystems. That is why modern fossil-fired, central electric generating stations have required well over 50 years to develop, with cooperation of manufacturers, utilities and design engineering firms all required to advance the state of the art.

For nuclear-powered electrical generating systems, significant penetration of the private sector required about 30 years, with very large Federal involvement in the riskiest subsystems: enriched fuel supply, reactor development, materials selection, quality control and safety, system control, spent fuel processing and radwaste storage. The last two are still not free enough of risk to attract private investment. The strongest support for nuclear system development came from the nuclear submarine program, fully funded by the Federal government. This program allowed development of the pressurized water reactor (PWR) system under Federal subsidy to the point that it now dominates the private nuclear generating market.

With this background perspective, the need for continued Federal involvement in the development of solar thermal systems for delivery of electricity process heat or fuels and chemicals is based on the following.

- There is no one industry or manufacturer that will take the risk of complete solar thermal systems R&D because no one industry will ever market complete utility systems and hence profit from manufacturing the entire system.

- For a group of industries to spread the development risk among themselves, they must be assured of a predictable market for their subsystems to be integrated into complete solar thermal electric systems.
- To generate the market required for individual company risk investment, the system users (e.g. utilities) must be convinced of system reliability and the O&M costs.
- If the market exists, manufacturers will work to get costs down to the point required for, say, competitive electricity production.

The critical step in this sequence is convincing the user of reliable operation and reasonable O&M costs. In other words, a pilot plant or demonstration plant is required. Such a plant also allows equipment and subsystem manufacturers to assess their production costs and to define the design and production improvements required to become competitive. On the other hand, the capital cost of solar demonstration plants is too large at this time for private industry to undertake except on a cost sharing basis.

This Panel believes that the role of integrating solar systems development and test must fall primarily to the Federal government, if it is ever to happen. History argues for it and demonstrates it in the case of nuclear power systems.

The inherent advantages of solar energy as a renewable, non-polluting, fixed-price energy source (once plant construction is complete) seem to us to be sufficient basis for continued Federal involvement.

In short, withdrawal of strong Federal support of solar thermal energy development will result in a serious slowdown of technical progress, risk reduction, private user acceptance and industrial commitment in the near term. In the long-term, such withdrawal precludes having the solar option in our energy resource mix when outside events beyond our control

(cut-off of oil imports) require its presence, or fossil energy cost escalation brings our standard of living and economic growth rate to unacceptable levels, or atmospheric pollution levels on a worldwide scale force us to develop this option under the pressure of time.

It is our collective opinion that these general arguments, based on the inherent nature of solar energy and the non-renewable, polluting nature of the alternatives, are sufficient for a national policy of serious commitment to development of solar thermal energy, both as a near term (1990's) option in favorable industries and regions and as the only currently demonstrable long-term alternative that we have. As stated at the outset of this paper, the principal benefit of solar thermal program is to increase the nation's energy producing options, thereby enhancing economic stability.

Recommended Structure of the Solar Thermal Program

The overall structure of the program is best perceived in terms of a near term component that is active through about 1986, and a long-term component geared toward the year 2000 and beyond.

The near term objective is the transfer of technology that has achieved technical and economic risk reduction through Federal support over the past nine years to the private sector. The longer term objective is to conceive and develop advanced solar thermal systems, their subsystems and components, for the purpose of a substantial reduction of technical complexity and risk and the consequent cost reductions.

For the near term, emphasis should be on the following items.

1) Measurement and evaluation of the major technical risks remaining in water/steam, molten salt and sodium central receiver technology for electric power production and cogeneration.
2) Evaluation of Barstow Pilot Plant operations to establish performance, operational requirements and O&M costs.

3) Design of solar-repowered utility generating stations sufficiently detailed to provide a basis for a cost shared repowering construction project. (See Constituency Programs, page 13).
4) Conceptual design of lower cost heliostats for the central receiver system. These designs should rely more on innovative uses of materials and possible relaxation of wind loading specifications than on mass production techniques.
5) Completion of the cost-shared modular industrial solar retrofit (MISR) program for trough collectors. The main purpose is to achieve further cost reduction potential in trough systems to the point of attracting full private sector investment.
6) Effective technology transfer programs for both the central receiver and trough systems. Both manufacturing and user industries should be involved. Information transfer to be based on what the private sector says they need.
7) Materials research in support of the technical and economic risk reduction efforts described in 1, 3 and 4, above.
8) Operation of outdoor, real-scale and real-time solar research facilities to obtain CR and trough system operating and performance data. These data should be sufficient to attract private sector investment.

[Note: Federal operation of these solar system research facilities for both near and long-term programs is essential for continued progress. Their relatively large scale is dictated by the inherent diffuseness of incident solar radiation. They are the minimum size needed for actual operation of experimental systems and subsystems at a meaningful level under real-time conditions.]

For the longer term, beginning in 1982 and continuing throughout the following two decades, emphasis should be on the following items.

(Key research areas for potentially significant cost reductions may be identified in the near term programs just described. In this event, they should be investigated to search for significant technical breakthroughs to bring about cost reductions.)

1) Advanced Systems for Production of Transportable Fuels and Chemicals Feedstocks.

The use of solar energy to produce hydrogen, methane and methanol from the renewable feedstocks, water, carbon dioxide and biomass would give the United States a fully renewable basis for manufacturing transportable fuels and chemical feedstocks. Furthermore, their production and use would be essentially non-polluting compared to either nuclear fission or fusion as primary energy sources. Therefore, perhaps the major long-term thrust for solar thermal R&D should be a parallel and coordinated effort to develop the production processes and the compatible solar energy sources to drive these processes. Both thermochemical and photochemical processes should be included in the research effort.

The research required to establish technical feasibility and to reduce technical risk should be defined in an initial, comprehensive effort that enlists the cooperation of basic researchers in both thermochemistry and photochemistry. The knowledge base for producing solar heat and concentrated beams of solar photon fluxes should be fully utilized in this research definition phase, which should require 1-2 years of concentrated effort.

Given the results of this definition phase, a carefully conceived research plan for solar fuels and chemicals production should be developed and implemented for the long-term.

2) Development of Parabolic Dish Technology

The market for this technology should be carefully reviewed and quantified. The potential reliability of operating large arrays of self-contained dish power modules should be established through small scale experiments at the point focus research facility. Emphasis should be placed on the two most promising small heat engines selected from Rankine, Brayton, and Stirling cycles. A reliable basis for estimating system costs by subsystem and component should be developed and a basis for supporting these numbers

established. The inherent advantages of modularity and smaller capital cost requirements for the dish technology should be exploited.

3) Development of Solar Pond Technology

Research on small scale ponds should be established at, say, the Solar Energy Research Institute, to develop an understanding of the requirements for maintaining salt salinity gradients and minimizing the effect of surface wind-induced wave motion on this gradient. Other areas of high technical risk should be identified and investigated. Concurrently, the potential market for this technology, both in the U. S. and abroad should be reviewed and quantified, bearing in mind the land areas required and location of nearby users of electricity and low temperature process heat. Continued research should be contingent on the potential for technical risk reduction and the existence of a market sufficient to require U. S. expertise and engineering capabilities for installation.

4) Long-Term High Temperature Storage Technology

The ability of stand-alone solar energy systems to operate and produce an end-use product (electricity, heat, fuels) at the least cost is directly proportional to the ability to store real-time solar energy as heat or in chemical compounds for use during periods of solar outage. Thermal energy storage technology for temperatures up to 540°C and times up to 8-10 hours is currently feasible utilizing molten salts. Also air/rock storage appears feasible and cost effective for times up to 100 hours. Confirmatory research on the air/rock concept is justified. Development of storage technologies at higher temperatures and for longer times is desirable, especially for those fuels and chemicals processes described under (4) above. If these transportable fuels and chemical feedstocks can be produced economically in stand-alone solar plants, then the storage of energy in these fuels, etc., automatically solves the storage problem at other points of use.

5) Continued Low Cost Collector Development

The major cost component in all solar energy systems is the collector

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subsystem, be they heliostats, dishes, troughs, flat plates or solar ponds. We recommend a continuing, long-term research effort to develop lower cost solar collectors through innovative concept design rather than through marginal improvement of existing designs.

6) Materials Research and Development
The ability of solar related components such as collectors, receivers and storage devices to operate reliably and to withstand their environment for 20-30 years or longer is critical to the desired risk reduction for solar energy systems. Furthermore, achievement of innovative collector design or high temperature solar process development will require a serious materials evaluation and selection effort. For these reasons, the Panel recommends a continuing program of materials R&D to support the long-range program defined above.

Priorities and Focus of the Program

The base solar thermal program should be focused in the near term on completing the transfer of the central receiver and trough technology developed over the past nine years to the private sector. This effort requires Federal participation as outlined under Steps 1 through 7, pages 9 and 10.

For the longer term, the focus should be on evaluation and possible development of parabolic dish and solar pond technologies if justified by the market potential for high payoff and the technical potential for risk reduction. A strong focus may develop out of the evaluation of solar fuels and chemicals production. Supporting programs in low cost collector development and materials research should accompany these priorities.

Constituency Programs

There exist strong constituencies in the solar thermal community which have been able to wield sufficient political power in the Congress to obtain budget allocations for specific solar projects. While it is in the nature of our political process that such things happen, the Review Panel has not hesitated to give their recommendations concerning them to the Director,

STES, whose job it is to fund and implement these projects. There are currently three projects which fit this description. Solar Repowering of gas and oil fired utility plants in the Southwest, the Small Community Power Systems Experiment and the Crosbyton Texas Hemispherical Bowl project.

Solar Repowering

Solar Repowering has, in fact, been a major objective of the DOE Solar Thermal Program for at least five years. Because of recent budget constraints and policy decisions, Repowering has been eliminated by the Administration as unnecessary and not consistent with their policy filter. On the other hand, the Review Panel has consistently given this program a high priority as the last step in transferring the central receiver technology to the private sector. The Federal solar thermal program, in cooperation with the utility industry and the industrial and manufacturing sector, has brought the CR technology through advanced R&D and a substantial program of component testing and development. In the opinion of the Panel the required repowering technology is only a small step away from the point where it can be moved from Federal support into the private sector and ultimately commercialization. The Panel believes it would be imprudent and a gross waste of Federal and private money, manpower and materials to abandon the Repowering program now when an additional small investment on the part of all the participants would complete this very important energy development.

The utility industry is not financially able to support the entire Solar Repowering program, and the manufacturing sector cannot accept the entire cost of development until a market for the product appears reasonable. The utilities, however, can support a significant portion (at least 1/4) of the cost based on potential savings in expensive fuels which would be displaced. The manufacturing companies have expressed a willingness to continue to participate in the cost of development to a significant degree. It should be possible to hold the Federal cost for Solar Repowering to approximately $100M in 1981 dollars over a five year period ending with 1986.

These are engineering, construction and start-up cost estimates and do not include DOE overhead costs.

The Panel is of the opinion that a commitment by the Federal government to partially support the Repowering program will elicit a strong base of support from the utility industry, both public and private, and the industrial, manufacturing and engineering concerns to provide the additional financial, technical and other resources necessary to move the concept into private industry.

Small Community Power Systems Experiment

This project has a history of about four years during which a PON was issued and six candidate sites were selected for this 1 MWe parabolic dish system. However, since this selection, no other activity has been evident, although budget appropriations continue to mention it. The Panel believes that either a site should be chosen during FY82 and a viable dish technology chosen for the experiment, or the whole project should be scrapped. The members have been concerned that the original schedules were far too optimistic with respect to the pace of the dish technology development, and we caution against promising more than can reasonably be delivered.

Crosbyton Hemispherical Bowl

In contrast to the Small Community Systems Experiment, the Crosbyton Project has moved along, and a successful demonstration of the hemispherical bowl technology was achieved about one year ago. The only problem with this technology seems to be its inherently lower efficiency when compared to the central receiver or parabolic dish and its lower annual average delivery of electrical energy. The Panel believes that this project should be terminated unless it can be demonstrated in FY82 that the performance and costs of energy are comparable to those expected from central receiver and parabolic dish technology.

Budget Recommendation

The Review Panel has not given recommendations in the past concerning specific budget levels for the individual DOE solar program elements. It does not propose to do so at this time. However, it does recommend that the total solar thermal program receive a base budget of at least $50 M/year, not including the "constituency programs" discussed in the preceding section. Such a budget would allow orderly implementation and sustainment of the recommendations given in this position paper.

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PROJECT DIRECTOR

CROSBYTON SOLAR POWER PROJECT

SOLAR THERMAL ELECTRIC POWER

SOLAR GRIDIRON (SOLAR BOWL) CONCEPT

DEPARTMENT OF ELECTRICAL ENGINEERING

TEXAS TECH UNIVERSITY

LUBBOCK, TEXAS

BEFORE THE

UNITED STATES HOUSE OF REPRESENTATIVES

SUBCOMMITTEE ON ENERGY DEVELOPMENT & APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

MARCH 1982

MR CHAIRMAN, I APPRECIATE THE OPPORTUNITY TO APPEAR BEFORE THE SUBCOMMITTEE TO DISCUSS THE CROSBYTON SOLAR POWER PROJECT (CSPP) CONDUCTED BY TEXAS TECH UNIVERSITY. I WILL MENTION SOME OF THE PROGRESS WE HAVE MADE AND HOPE TO CONVEY THE IMPORTANCE OF CONTINUING THIS RESEARCH EFFORT.

THE CROSBYTON SOLAR POWER PROJECT HAS NOW DEVELOPED THE SOLAR GRIDIRON OR SOLAR BOWL CONCEPT TO THE POINT WHERE A PRELIMINARY DESIGN FOR A 5MWe SOLAR-FOSSIL FUEL HYBRID ELECTRIC POWER PLANT HAS BEEN COMPLETED AND DELIVERED TO THE USDOE. THIS EFFORT COMPLETED THE FOURTH GENERATION OF CONCEPTUAL DESIGN FOR HIGH TEMPERATURE SOLAR

GRIDIRON APPLICATION. THE ADVS (ANALOG DESIGN VERIFICATION SYSTEM), OPERATED FOR THE FIRST TIME ON JANUARY 23, 1980 AT CROSBYTON, TEXAS, EXEMPLIFIED AND TESTED THE SECOND GENERATION OF DESIGN CONCEPTION. THE CHANGES FROM GENERATION TO GENERATION HAVE RESULTED FROM INCREASED EXPERIENCE WITH THE BASIC CONCEPT AND UNDERSTANDING OF HOW THE COST OF SYSTEMS MIGHT BE REDUCED. SUCH A 'SERIES EFFORT' WAS PLANNED IN THE ORIGINAL PROPOSAL TO THE ERDA IN 1975.

THE COST FROM INCEPTION IN FY 75 THROUGH FY 81, THROUGH COMPLETION OF THE PRELIMINARY DESIGN, WAS $6M, ALL OF WHICH WAS PROVIDED BY THE ERDA/USDOE. THIS IS A VIGOROUS PROGRAM CONDUCTED BY TEXAS TECH UNIVERSITY WITH SUBSTANTIAL BENEFIT FROM THE FINE EFFORTS OF INDUSTRIAL SUBCONTRACTORS: E-SYSTEMS OF GARLAND, TEXAS AND FOSTER-WHEELER ENERGY CORPORATION OF LIVINGSTON, NEW JERSEY. THE ADVS CONTAINS THE LARGEST PRIMARY SOLAR COLLECTOR EVER BUILT. THIS COLLECTION SYSTEM FULFILLED EVERY DESIGN EXPECTATION AND HAS BEEN EXTREMELY SUCCESSFUL AND IMPORTANT AS A LEARNING AND RESEARCH DEVICE. IT HAS BEEN OPERATED CONTINUOUSLY FOR OVER 26 MONTHS NOW AND HAS BEEN OBSERVED BY APPROXIMATELY 10,000 VISITORS. THROUGHOUT ITS OPERATIONAL LIFE TO DATE, IT HAS PROVIDED PROJECT PERSONNEL WITH THE ONLY SYSTEM LEVEL EXPERIENCE IN THE WORLD WITH A HIGH-TEMPERATURE SOLAR SYSTEM UNDER DAILY OPERATION AND THE ONLY EXPERIENCE WITH DAILY CONTROL OF A HIGH-TEMPERATURE SOLAR BOILER. ON MARCH 23,

1981 THIS SYSTEM PRODUCED THE FIRST COMMERCIAL ELECTRICITY FROM SOLAR STEAM IN THE NATION'S HISTORY.

SO THAT TEXAS TECH COULD PROCEED WITH THE DEVELOPMENT OF THIS TECHNOLOGY, $4M WAS AUTHORIZED AND APPROPRIATED FOR FY 82. IT IS NOW THE MID-POINT OF FY 82, AND THESE FUNDS HAVE NOT YET BEEN DEPLOYED AND ARE NOT YET AVAILABLE TO TEXAS TECH. THE PROGRAM IS OBVIOUSLY IN A PRECARIOUS POSITION AND IN GREAT PERIL BECAUSE OF THE DELAY IN FUNDING. WE HOPE THAT VIGOROUS ACTION WILL BE POSSIBLE AGAIN SOON. THE FUNDS ARE NEEDED BADLY.

THESE FUNDS PLUS THE $1M REQUESTED NOW FOR FY 83 ARE NEEDED TO DEVELOP VARIOUS COMPONENTS AND CONTINUE RESEARCH INTO METHODS FOR COST REDUCTION. THE ITERATED DESIGN APPROACH OF THE PAST SEVEN YEARS HAS REFINED THE BASIC CONCEPTION OF HOW TO SUCCESSFULLY ENGINEER A COST EFFECTIVE SYSTEM. REALISM HAS ALWAYS BEEN KEPT FOREMOST IN THE RESEARCH AND DEVELOPMENT BY FOCUSING ON A 5MWe POWER PLANT APPLICATION. THE CRUCIAL PARAMETER FOR DEVELOPMENT IS THE PRICE OF THE ELECTRICITY. ALTHOUGH EFFICIENCY IS ALWAYS OF INTEREST, THERE ARE LIMITS TO THE OPPORTUNITY FOR EFFICIENCY IMPROVEMENT. PEOPLE DO NOT BUY EFFICIENCY; THEY BUY ELECTRICITY. FOR THE PAST SEVERAL YEARS, THE EFFORTS OF THE CSPP HAVE EMPHASIZED COST REDUCTION IN ORDER TO MINIMIZE THE PRICE OF ELECTRICITY. THIS CONCEPT, AS PRESENTED IN THE PRELIMINARY DESIGN, IS NOW ABLE TO PROVIDE ELECTRICITY AT A LOWER PRICE THAN WOULD BE POSSIBLE FOR ANY OTHER KNOWN

HIGH-TEMPERATURE SOLAR THERMAL TECHNOLOGY. NOW THAT THE ITERATION OF THE BASIC CONCEPTIONS HAS ESTABLISHED THE OVERALL ROLE AND INTERPLAY OF THE COMPONENTS, IT IS NECESSARY TO USE PARALLEL EFFORTS AND COMPETE THE FINAL DEFINITION OF SOME OF THE INDIVIDUAL COMPONENTS.

THE COST OF A 5MWe POWER PLANT BASED ON THE PRELIMINARY DESIGN, INCLUDING FINAL DESIGN AND OTHER "FIRST OF ITS KIND" COSTS, HAS BEEN DETERMINED BY TEXAS TECH TO BE $35M. THIS COST WAS VERIFIED BY USDOE IN 1981 BY AN INDEPENDENT COST STUDY CONDUCTED BY A. T. KEARNEY, INC. OF CHICAGO/NEW YORK.

THE NEXT STEPS REQUIRED TO DEVELOP THIS TECHNOLOGY INVOLVE:

- FURTHER DEVELOPMENT AND DETAILED DESIGN OF SOLAR COMPONENTS;
- FABRICATION OF A FULL-SCALE (59-FOOT LONG) SOLAR BOILER AND CONDUCT OF SIMULATION TESTS;
- COMPETITIVE DEVELOPMENT OF MIRROR PANELS WITH EMPHASIS ON COST AND LIFETIME;
- FABRICATION OF FULL-SCALE SUPERPANELS WITH EMPHASIS ON STRUCTURAL PROPERTIES, PANEL INSTALLATION TECHNIQUE AND LABOR, PANEL ACCURACY AND PREALIGNMENT TECHNIQUE AND LABOR;
- DEVELOPMENT OF CONTROL SYSTEM TECHNIQUES, ALGORITHMS, AND HARDWARE;

- CONTINUED USE OF THE ADVS FOR TESTING OF POTENTIAL COST REDUCTION OPTIONS; AND MANAGEMENT OF THE EFFORTS.

FOR THESE PURPOSES THE $4M FOR FY 82 IS NEEDED, ALONG WITH THE $1M REQUESTED FOR FY 83.

IT SHOULD BE STRESSED AGAIN: THE PROBLEM WITH SOLAR TECHNOLOGY IS THE COST OF ELECTRICITY. THE GREATEST EMPHASIS OF THE CSPP IS, THEREFORE, ON THIS MATTER: SYSTEM COST REDUCTION. THE SUPERPANEL CONCEPT DEVELOPED IN 1981 HAS HAD GREAT IMPACT ON SYSTEM COST. CONTINUED DEVELOPMENT OF THIS IDEA IS EXTREMELY IMPORTANT. THE WORK OF THE CSPP IS IN THE HIGH RISK/HIGH PAYOFF CATEGORY PRESENTLY EMPHASIZED BY NATIONAL POLICY. THE HIGH PAYOFF IS NOT IN PERFORMANCE IMPROVEMENTS, BUT IN THE AREA OF SYSTEM COST. THE RISK IS THAT THE DESIGN APPROACHES AND DESIGN FEATURES MAY NOT SERVE UP TO EXPECTATION IN REDUCING POTENTIAL SYSTEM COST. AS STATED ABOVE, THE SOLAR GRIDIRON CONCEPT AS ENGINEERED BY THE CSPP IS ALREADY ABLE TO OFFER THE LOWEST POTENTIAL ELECTRICITY COST OF THE COMPETING SOLAR-THERMAL CONCEPTS, BUT THE OUTSTANDING ISSUE REQUIRING ADDITIONAL R&D IS WHETHER SUCH ELECTRICITY CAN BE DELIVERED AT A PRICE THAT CONSUMERS CAN AFFORD.

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SEIA

TESTIMONY OF THE SOLAR ENERGY INDUSTRIES ASSOCIATION
PRESENTED BY R. NICHOLAS LOOPE, PRESIDENT
BEFORE THE ENERGY CONSERVATION AND POWER SUBCOMMITTEE
HOUSE ENERGY AND COMMERCE COMMITTEE

I am pleased to appear before the subcommittee today to present the testimony of the Solar Energy Industries Association (SEIA), of which I have the pleasure to be the current national President. My name is R. Nicholas Loope and I am the chief executive officer of Sunworks, Inc., a subsidiary of American Smelting and Refining Co. Many of the Fortune 500 companies are involved in solar energy because they see the future of energy production from this source.

SEIA is a membership trade association representing the interests of the solar businesses of our nation. We include among our membership producers of solar equipment, research and development interests, marketing interests, and those involved with the installation of solar equipment. We represent companies which produce between 80 to 90% of all the solar equipment manufactured in the United States. SEIA has in its membership both large, medium and small companies, with about 85% of our members being properly classified as small businesses.

SEIA is in its eighth year of operation and provides many membership services to the 500 members, most of which are company members. The association is divided into various division units representing the different solar technologies.

INDUSTRY PHILOSOPHY ON GOVERNMENT PROGRAMS

Before I comment directly upon the budget issues which are before the subcommittee for determination regarding solar energy, let me make a brief statement regarding the general philosophy of the solar industry toward government programs for solar energy.

While there were a few scattered solar companies in the United States before the oil crisis of 1973-74, it was not until that time that American business became serious about building a solar industry. From that point on the Federal government was supportive of developing the technology for renewable energy resources and helping to encourage the establishment of a privately-financed solar industry. In the ensuing years, a build-up in support for solar energy research, development and demonstration was seen. The private sector responded by pouring money into the manufacture of solar equipment and marketing systems for the same. As a result, the flat plate collector, photovoltaic, solar thermal electric and wind technologies started to develop a small industry base. Other technologies were still being developed for commercialization, as well. And the federal government's role in the beginning of all of this was, necessarily, substantial and justified.

Now, some technologies have been well developed and are being commercialized or marketed by the private sector, without great need for the commitment of large federal government budgets. But, other technologies are still in the research and development stages and have a continued need for federal goverment involvement.

SEIA believes that certain research and development functions are clearly within the continued role of the federal government. SEIA believes that commercialization and marketing functions are within the role of the private sector. But, in the case of the new solar industry, it is sometimes hard to draw a clear line between these functions since they are closely inter-related. Some of the functions that still need government funding fit into the

category between these two functions and could be referred to as "transition functions".

The solar industry of the United States is not looking for a free ride from the federal government. Solar energy is an efficient, cost-effective source of energy that has many advantages. It can now, in many instances, compete successfully against other fuel sources, and it will be able to successfully compete against others, in the near future. We are not, however, dealing with a free market for energy. Other forms of energy are receiving substantial subsidies that distort the picture for solar comparisons. If those subsidies continue, therefore, those of us in the solar industry feel that, at this time, it is still necessary and justified for the federal government to continue its role in solar energy to assist in further researching and developing the technologies, and providing the necessary transition to the private sector so that those worthwhile and cost-effective technologies may be successfully marketed by American businesses.

GENERAL VIEWS ON FY 1983 BUDGET

SEIA feels that the $72 million level in the Administration's budget request is far below an acceptable budget for solar energy in FY 1983. Last year, SEIA supported substantial budget cuts across the board in the federal government, including solar energy, believing that it was necessary for good fiscal management in the government. Later, it was recognized that the budget cuts in the energy technologies was not an even-handed program. Solar energy and the renewable forms took more severe cuts than other energy technologies.

It is not possible this year to make those same size cuts and keep a viable solar energy program in existence. It is necessary that the United States commit itself to a balanced energy program, giving support and development of all viable energy technologies. Our experience during the oil crises of 1973-74 showed that the overnight planning and mad scramble approach to solving energy problems is not the best way. We need to sustain a balanced program for the advancement of solar energy so that it can be counted for a substantial part of energy production soon.

While it is difficult for those of us outside the federal government to know all the answers to the complex problems of devising adequate and fair federal budgets, SEIA has carefully weighed the Administration's proposals and also information about the present status of DOE programs for solar energy. Also, SEIA has considered the state of the art in various technologies, and what the legitimate needs are in those areas during the next fiscal year period. After that treatment by the Government Relations Committee of SEIA, and after approval of its Executive Committee, the following recommendations are made regarding the FY 1983 budget.

Believing that the FY 1982 budget figure passed by the Congress and signed last December by President Reagan, represented a very lean, yet basic solar budget, SEIA recommends that the FY 1983 budget level for solar energy should not be less than $275 million, which was the FY 1982 figure. The chart attached to this statement gives the various recommendations for the technologies and functions, and provides additional detail for the subcommittee. I will now briefly comment on some of the more important sections of our recommendations.

ACTIVE AND PASSIVE SOLAR TECHNOLOGIES

SEIA is recommending to the subcommittee that there is a valid need for funds to be authorized and appropriated to assist the development of active and passive solar technologies in a new context which we call a "Solar Building Technology Program." This concept would combine monies previously used for both active and passive solar programs at DOE, and utilize them in an integrated approach to solving building energy problems. There is great support for doing this type of research and development within the solar industry and within the housing and construction industries as well.

While the technology for active solar systems is well developed, there are still some important research and development functions that should be continued. The development of low-cost materials which improve the performance, reduce weight and reduce costs are important. The great number of solar companies, being small companies, do not have the necessary capital resources to undertake this function. Additional work on development of more efficiency in solar cooling systems needs to be continued as well.

Research and development is needed in passive solar residential cooling and in commercial-scale heating and cooling applications. Improvement in the performance and reduction in cost of passive solar construction materials is important as well. The private sector is involved in these areas, but needs the federal government partnership to continue this work.

These and other accomplishments could be made for active and passive solar technologies through the combination of funds for these programs under a new program called "Solar Building

Technology Program".

As a part of that program SEIA recommends that there should be a continuation, with new emphasis, on the Federal Buildings Program which was started a number of years ago. This program authorizes the solar retrofit on many existing federal buildings that can be improved in energy effieiency by the addition of solar features.

SEIA recommends that the same level of funding for Active and Passive programs be authorized, as in FY 1982, which would be $11.5 million for Active and $10.6 million for Passive. SEIA also recommends that the Federal Buildings Program be funded at a figure of $40 million.

PHOTOVOLTAIC TECHNOLOGY

Photovoltaic cells are increasing in efficiency which is being achieved both in production processes and in the performance of systems themselves. The necessary areas of continued research and development includes work on amorphous silicon for thin film solar cells including tandem devices; polychrystalline thin film solar cells including copper indium di selenide zinc phosphide; and advanced devices, including amorphous organic solar cells and luminescent solar concentrators. Also important is the development in insolation data base on a worldwide scale from satellite data, and the collection of data and its analysis from existing photovoltaic installations. The development of a uniform system of performance criteria and new module testing and standards should also receive support.

SEIA also believes that it is important to continue the SMUD program building upon the planning and funding of previous years. The total funding recommendation for the photovoltaic activities is $46.0 million.

SOLAR THERMAL ELECTRIC TECHNOLOGY

Most of the technologies whthin solar thermal electric fall within one of three categories: linear focusing receivers; point focusing distributed receivers; and central receiving stations.

The operation of Solar I (Barstow project) is a crucial step in the development of the central receiver concept and in getting the technology transferred to the private sector. Further, the industry feels that the central receiver technology is close to, but not yet at, the point at which it can be turned over to the private sector. There exist several principle technical/cost barriers to its acceptance.

A very important step in eliminating these uncertainties is government support, in conjunction with significant cost sharing on the part of the private sector, for preliminary design of at least two solar power plants. This effort would keep the repowering effort moving forward by the industry and build the prospect for its expansion.

The parabolic dish technology should be supported through continuation of the small communities program, by which the chosen communities would contract directly with the industry to install and operate the maximum number possible of experimental modules by leveraging the limited federal funds with available venture capital. Also, we support the testing of a fully integrated parabolic Brayton module.

SEIA believes that it is important to continue the solar research facilities. The Central Receiver Research Facility in Albuquerque; Solar Thermal Test Facilities Users Association, in supporting work at the Advanced Component Test Facility at Georgia Institute of Technology; and other research work ongoing at White Sands Solar Furnace near Las Cruces, N.M., and at the Test Bed Concentrators at Edwards Air Force Base, CA, should all be supported.

Additional research needs to be done on the receiver located on the top of the tower of a central receiver system. Also, included in this package of necessary research is the steam generator used in the system and also the storage concept which must be low in cost and economically viable.

A small amount of additional money should be allocated during this fiscal year to complete the Shenandoah project in Georgia. This project then should be ready to provide the user community with confidence that the generic dish concept can be operated effectively.

Other work which needs to be continued is the parabolic dish concentrator. The second-generation heliostat study has produced significant advancements in the central receiver technology, and it is felt that similar results are possible here if undertaken.

SEIA further recommends materials research for troughs in order to develop improved absorbers, reflectors, etc. As a part of the work on solar troughs, it is recommended that data acquisition and other ongoing data work continue in order ot obtain useful data on system performance, degradation with time, reliability, and maintainability.

Work should also be supported on developing parabolic dish hybrid receivers using natural gas fuel, with development toward using other low-cost fuels other than natural gas.

Industry encourages DOE to become fully aware of the applicable heat engine and materials recearch being conducted by DOD. Some of this data could be utilized and the transfer of the data should be made at a small cost.

Additional research and development should also continue on the glass-type heliostat. Among other technical issues is the adequacy of the seal between the reflective glass element and its backing.

Some additional work should be done in the area of solar assisted production of fuels and chemicals, but it should not have a high priority since it cannot have a near-term impact on stabilization of energy prices or on energy independence.

Some additional work should also continue in the salt pond research already ongoing but at a fairly low level at this time.

For all of the areas mentioned in the solar thermal electric technology, SEIA recommends funding at the level of $59.5 million.

INTERNATIONAL

The Administration's budget provides funds in the international area for funding the solar program with Saudi Arabia known as the Solaris Program, but does not seem to provide funding for the very important international support of solar industry exports. In 1980 solar industry exports totaled $36.1 million with the great part of that business coming in photovoltaics.

The International Market Development program in the Department of Commerce had conducted a series of overseas shows and seminars

which have produced immediate sales of approximately $3 million and from which participants projected 12 month future sales of about $60 million.

A reinvigorated market development program for renewable energy products in the Department of Commerce, would represent the single most, cost effective, way to promote solar products abroad. The leverage of each tax dollar spent on such an effort will benefit our balance of trade and the growth of the solar industry.

SEIA recommends a total of $11.5 million for this activity which would fund the Solaris Program at $9.5 million and provide $2.0 million for the international trade program described above.

OTHER BUDGET CATEGORIES

Time will not permit a detailed description of other programs in the solar section of the Department of Energy budget. SEIA does support some funding for other technologies as shown by the attached chart, including wind, biomass, alcohol fuels, ocean thermal, and the solar information program. It is also suggested that the Congress may again want to include a Solar Reserve account which has proved useful as a contingency fund for small matters worthy of consideration,with congressional approval.

RATIONALE FOR SOLAR BUDGET SUPPORT

At a time when our nation seems to have recurring economic troubles and solutions are not abundant, the questions might well be raised: "Why should solar energy continue to be supported at all by the federal government? Is the government's work in solar, one of the expendable budget items?" SEIA's answer to that is similar

to the excellent comments made by members of this subcommittee and some of the witnesses that appeared before you earlier this year when you conducted several days of preliminary hearings on the impact of the Administration's budget cuts on solar and conservation programs.

This nation is still dependent to an alarming degree upon unstable foreign oil supplies. That dependence is expensive and it is insecure for this nation, given the political instability of the Middle-East. The United States need not repeat old mistakes of ignoring its mounting energy problems. The preparation for moving from foreign oil dependence could have been made before the oil crisis of 1973-74, but few people including the federal government wanted to listen or act. Now that we have made a start toward building a renewable energy base in the United States, should we abandon that substantial start and become more vulnerable to repeated energy crises that may lie in the future?

President Reagan has asked that 74% of the energy budget be spent on one energy technology. That imbalance in the use of the scarce federal funds must be looked at closely by the Congress. Can we afford that kind of singular approach to a problem that already requires all energy technologies to be utilized to their fullest extent to meet present requirements?

All of this drastic reduction in the federal solar budget is requested when at the same time the Administration is also calling for the repeal of the business energy tax credits which provide for a 15% tax credit for the use of solar on commercial, industrial or business structures. The Administration continues to justify its reduction in program funds at the Department of Energy by saying that the tax credits will suffice. Certainly, the tax credits are

important and the industry needs them. They should continue in place because they are working for the purpose intended - as an incentive to move energy users to the renewable energy sources. But, it is ludicrous to use the argument of the tax credits as a reason for budget reductions, when the official policy apparently is clear that both should be eliminated.

CONCLUSION

This subcommittee and indeed the entire Congress of the United States has an important annual responsibility to review the various requests for funds within the government and to wisely weigh each request. SEIA supports that procedure and is pleased to participate in it. We have faith that any objective look at the energy needs of our nation, the instability of sources of our imported oil, the economy of our nation, and the advantages of solar energy, would lead to the conclusion that a balanced, aggressive approach is necessary in our energy policy today, not retreat from reality.

SEIA, therefore, recommends that this committee support a balanced budgeting of funds for solar energy, not less than the $275 million figure carried in FY 1982, to move our country toward a broader base of domestically-produced, cost effective, solar energy in the years to come.

SOLAR ENERGY INDUSTRIES ASSOCIATION
FY 83 SOLAR BUDGET RECOMMENDATIONS

(In Millions)

	Administration	SEIA
Active Heating & Cooling	$ 0.0	$ 11.5
Solar Buildings Program	0.0	40.0
Passive	0.0	10.6
Solar Thermal	18.4	59.5
Photovoltaics	27.6	46.0
Wind	5.6	35.4
Alcohol & Biomass	9.75	25.0
OTEC	0.0	20.8
International	9.5	11.5
Information	0.0	5.0
Program Direction	2.14	0.0
TOTAL	$ 72.9	$ 265.3

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Chatsworth, California 91311
Telephone 213 700 7350

Elliot Berman
Chief Scientist

March 3, 1982

Dear SEIA PV Division Member:

On March 16 I will be testifying before Congress on the PV industries' opinion of needs for the National PV Program. I will be appearing before the House Committee on Science and Technology Subcommittee on Energy Development and Applications. In order to fairly represent industries' views on PV AR&D I would appreciate knowing your opinion of the potential for new scientific understanding, the potential impact of the work on further technology development, and the federal funding priority to be accorded work in the various AR&D areas. In this context the objective for AR&D photovoltaics is defined as follows:

> "to conduct high risk, high payoff research and development on photovoltaic concepts in order to advance scientific understanding and to establish a technology base from which private enterprise may choose energy production options for further technology development and introduction into the competitive energy market".

Attached is further information about the three questions concerning scientific understanding, potential impact and federal funding priority. The remaining pages contain descriptions of AR&D activities in photovoltaics along with the three evaluation questions for each area. You need only to circle your responses to the three questions in each area and return the completed form as soon as possible. I will need your inputs by midweek next week for inclusion in my testimony.

If you feel that you would rather not be identified with your responses, please complete and return the questionnaire anonymously. However, the information will be more valuable to us if you do tell us who you are, for whom you work, and how we can reach you for further information.

Your cooperation will be greatly appreciated.

Sincerely,

Dr. Elliot Berman
Chairman, SEIA Photovoltaics Division

EVALUATION GUIDELINES

Please circle your response to the three questions following the description of each of the 35 R&D activities listed on the attached sheets. Feel free to make additional comments.

The three questions following the R&D descriptions are repeated below. The abbreviated responses are underlined.

CONTRIBUTION TO BASIC SCIENTIFIC UNDERSTANDING

Very Likely	to produce significant advances, discoveries and/or breakthroughs
Likely	to add fundamental knowledge
Not Likely	to add new knowledge

POTENTIAL IMPACT (IN 5 YEARS OR MORE) ON FURTHER TECHNOLOGY DEVELOPMENT BY PRIVATE INDUSTRY

Excellent	probability of significant impact
Probable	that positive or indirect impact will result
Unlikely	to have any impact

PRIORITIES FOR FEDERAL AR&D FUNDING

Very High Priority	must be funded regardless of the total budget available
High Priority	should be funded if at all possible
Medium Priority	would be nice to fund if adequate funds exist
Low Priority	should be funded only under the highest budget scenario
Very Low Priority	should not be funded

I. Physics of PV Materials and Structures

A. III-V COMPOUND SEMICONDUCTORS MATERIALS FOR HIGH EFFICIENCY PHOTOVOLTAIC CELLS

This includes studies of nucleation and growth, dopant incorporation, defect density reduction, lattice mismatched growths, stressed layers and substrate development. Materials should include binary, ternary, and quartenary III-V compounds, thin polycrystalline films and thin films on reusable or sacrificial substrates.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

B. RESEARCH ON COPPER INDIUM DISELENIDE ($CuInSe_2$) CELL STRUCTURES AND FABRICATION

This includes alternate deposition by direct or reactive sputtering, chemical vapor deposition, thermal evaporation, including uniform source, planetary evaporation, hot wall vacuum evaporation, spray pyrolysis and electrodeposition; laser processing; substrate development including rigid and flexible substrates, lattice and thermal-expansion matching; grid design and AR coating optimization; and device research including frontwall vs backwall cell designs and heterojunction cell modeling.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

C. LIGHT INDUCED CHANGES IN AMORPHOUS SILICON (a-Si) AND EFFECTS ON SOLAR CELL STABILITY

Identify causes contributing to light induced changes by investigating the role of hydrogen, impurities, impurity complexes, interface states and barriers.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

D. FUNDAMENTAL STUDIES IN III-V COMPOUND SEMICONDUCTOR MATERIALS AND SOLAR CELLS

This includes evaluations of grain boundary effects and surface and bulk defects, defect passivation techniques, modeling of current transport and cell performance, studies of high injection effects, and analysis of novel structures for high solar cell efficiencies.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

E. BASIC STUDIES IN COPPER INDIUM DISELENIDE ($CuInSe_2$)

This includes single crystal studies for enhancing open circuit voltage, thermodynamic solid-vapor equilibrium research, research on (Cd,Zn)S or CdS heterojunction partners and corresponding interface properties, surface treatments and annealing studies, minority carrier lifetime studies, research in majority carrier properties, grain boundary characterization and passivation, component substitution research, effects of impurity migration and variations in stoichiometry, stability studies, and theoretical band structure calculations.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

F. INTERFACE PROBLEMS ASSOCIATED WITH AMORPHOUS SILICON PHOTOVOLTAIC DEVICES

Develop stable transparent conducting films for contact window layers, control and understand interfaces between substrate and superstrate layers and amorphous silicon and explore possible interface effects between doped and undoped amorphous silicon layers.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

G. FUNDAMENTAL PHOTOELECTROCHEMICAL PROCESSES

Understand the energetic and kinetic factors controlling charge transfer at the semiconductor/electrolyte interface, characterize semiconductor surface states and elucidate their effect on photoelectrochemical cell parameters, understand the effects of various semiconductor surface modification approaches, and model semiconductor photoelectrode behavior.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

H. DEFECT PASSIVATION AND MATERIALS MODIFICATION FOR POLYCRYSTALLINE SILICON

This includes understanding mechanisms of hydrogen incorporation in grain boundaries (amount, location, structural and electrical effects), understanding laser processing for precise dopant profile and control, and incorporation and effect of passivating agents other than hydrogen.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

I. STRUCTURAL ELEMENTS OF HIGH EFFICIENCY PHOTOVOLTAIC CELLS

Research to include contact metallurgy for high concentration cells, optical coatings, cascade and multijunction cell interconnects, and junction formation.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

J. BASIC MECHANISMS IN POLYCRYSTALLINE SILICON

This includes understanding of selected electrically active grain boundary structures and other defects, such as dislocation networks; effects of thermal history on grain boundary electrical activity, and impurity segregation and diffusion; effects associated with very high doping levels in silicon; and modelling of polycrystalline silicon solar cell performance, resolving discrepancies between theoretical and actual efficiencies.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

K. DEPOSITION METHODS FOR AMORPHOUS FILMS

Investigate alternate deposition methods such as sputtering and CVD by studying deposition rate, uniformity, chemistry of film growth, deposition parameters, material utilization, scaleability, gas depletion, and defect control. Conduct research on plasma dynamics in large area high deposition rate glow discharge and the effects of glow discharge parameters on film properties. Alternate device structures such as series connected and stacked cells and conventional homojunctions will be employed.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

L. MATERIAL CHARACTERIZATION AND THEORETICAL UNDERSTANDING OF THIN FILM AMORPHOUS MATERIALS

Investigate specialized material characterization techniques such as SIMS profiling, surface photovoltage depth profiling, surface photovoltage hole diffusion lengths, surface and interface diagnostics, plasma diagnostics and methods of determining gap state distribution, and develop a theoretical base for guiding further research activities.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

M. CELL PHYSICS IN CRYSTALLINE SILICON

This includes understanding of limits of obtainable efficiency, two and three dimensional computer modelling of current transport phenomena, physics and stability of inversion layer silicon solar cells and other novel device structures, and increase in photoconversion efficiency obtainable by passivation of grain boundaries with hydrogen as a function of grain size.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

N. POLYCRYSTALLINE THIN FILMS FOR PHOTOELECTROCHEMICAL SOLAR CELLS

Research in this area includes: investigation of deposition techniques including co-evaporation, electrodeposition, chemical bath deposition, and chemical spray deposition; correlations between deposition parameters and film properties; fundamental limitations on thin film efficiency; problems related to scaleability of films deposited on metallic and optically transparent conducting substrates; and exploration of new photoelectrochemical thin film materials.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

95-882 O—82——71

O. CONTINUED RESEARCH ON CdS/Cu_2S

This includes materials and device studies on heterojunction with CdS and (Cd,Zn)S, development of alternate deposition techniques for CdS and (Cd,Zn)S including sputtering and co-evaporation, intrinsic stability studies, encapsulation research, research in all-sputtered and hybrid devices, and surface treatments and annealing studies.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

P. SILICON SOURCE MATERIAL RESEARCH

Advanced research will be continued on polycrystalline purification processes utilizing fluidized bed reactor and free-space reactor synthesis of semiconductor powders from gases, electrochemical purification of low grade precursors, and other new material synthesis approaches.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent	Probable			Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

Q. ENCAPSULANT RESEARCH

This research activity will include combined effort at improved ultra-violet stability of polymeric films such as long term stability of the absorbers of polymeric chains, anti-soiling materials and proper surface treatments involving attachment of stable moleculor species, and interface stability of environmental isolation systems through the understanding of the nature and distribution of the stresses on these interfaces and formation of chemical/mechanical bonds across them.

Contribution to Basic Scientific Understanding	Very likely		Likely	Not likely	
Potential Impact on Further Technology Development by Private Industry	Excellent	Probable		Unlikely	
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

II. INNOVATIVE CONCEPTS RESEARCH

A. ALTERNATE POLYCRYSTALLINE THIN FILM PHOTOVOLTAIC MATERIALS

This includes basic studies on CdTe materials and devices, contacting to p-type CdTe, controlled film growth and doping, alternate film growth techniques including hot-wall vacuum evaporation, chemical vapor deposition and electrodeposition, device optimization with heterojunction partners such as CdS or (Cd,Zn)S and corresponding interface studies; controlled deposition and doping of Zn_3P_2, research on heterojunction partners such as ZnSe and corresponding interface studies, and contacting research; materials and device research on $Cu_{2-x}Se_x$ including heterojunction partner studies on CdS or (Cd,Zn)S and corresponding interfaces; materials and device research on CdTe/CdSe solid solutions with heterojunction partner studies; materials and device research on $ZnSiAs_2$/Si cascade cells, and materials and device research on variable bandgap $Pb_{1-x}Cd_xS$ homojunctions and heterojunctions.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

B. NEW AMORPHOUS MATERIALS

Investigate amorphous alloys with more favorable bandgaps such as Si-Ge for use in higher efficiency cascade cells and wide bandgap window materials such as Si-C and microcrystalline doped layers which would be less absorptive.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

C. PHOTOCHEMICAL RESEARCH ON LUMINESCENCE IN SOLIDS

Investigate dye/host interactions, energy transfer, electron transfer, quantum efficiencies, degradation and quenching effects for materials in non-tracking luminescent concentrators.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

D. PHOTOELECTROCHEMICAL CELL STABILITY

Establish and identify cell degradation mechanisms and identify thermodynamic and kinetic factors controlling stability behavior, explore innovative approaches to enhance stability such as semiconductor post-deposition treatments and surface modification approaches, and perform long term stability studies for promising systems.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

E. OTHER RESEARCH IN PHOTOELECTROCHEMICAL CELLS

Research on new materials with properties specifically designed for photoelectrochemical applications including high efficiency polycrystalline thin film, p-type photocathode materials, counterelectrode materials, cell encapsulation, alternate electrolytes including nonaqueous and molten salt electrolytes and tailor-made redox couples for specific applications, and studies for photoelectrosynthetic production of storable high energy chemical fuels.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

F. SILICON MATERIAL GROWTH

This includes research on basic understanding of silicon ribbon growth by novel high throughput techniques including control of crystallographic, electrical, and morphological defects and novel methods of silicon thin-film deposition such as photoassisted chemical vapor deposition and preparation of microcrystalline materials, low angle ribbon growth, and directed energy beam heated crystal growth.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

G. LUMINESCENT CONCENTRATORS

This includes synthesis of organic dyes and polymer hosts, fabrication and analysis of inorganic luminescent material, optical coupling into and out of the collector and detailed analysis and modeling.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

H. PHOTOELECTROCHEMICAL STORAGE

Research in this area includes: characterization of new and innovative photoelectrochemical storage systems such as three electrode and redox systems; investigations of solar conversion and storage efficiencies, charge/discharge cycling parameters, storage capacities, and cell polarization characteristics; identification and characterization of membrane separator materials; and investigations of hybrid thermal/photoelectrochemical concepts.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

I. ORGANIC MATERIALS AND DEVICES

This includes studies on monomeric and polymeric organic photoconductors such as merocyanine dyes, phthalocyanines, charge-transfer complexes including those with trinitrofluorenone as an acceptor, and composite materials including polymers with dispersed conventional photoconductors; photovoltaic device studies including Schottky barriers and heterojunctions; theoretical modelling including effects of field dependent generation and geminate recombination; minority and majority transport studies; interfacial and grain boundary research; contacting studies; and effects of impurities.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

J. CONCENTRATOR CELL OPTIMIZATION

Research in this area will be continued to optimize the structure and fabrication of PV cells, both silicon and AlGaAs cells, that are unique to concentrator collectors operating under high solar flux conditions. This includes optimization of electronic properties of cell materials, innovative cell structures such as etched multiple vertical junction (EMVJ), interdigitated back contact (IBC), and beam splitters for an improvement of concentrator cell efficiencies, and computer analysis of two dimensional current flows and high carrier injection regimes.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent	Probable			Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

K. NEW CONCEPTS

Research on new PV conversion concepts, new structures and geometries for the basic conversion elements (e.g., new cell geometries), new materials, new junction formation techniques, new fabrication processes and new material deposition methods.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

III. SUPPORTING RESEARCH AND MEASUREMENTS

A. INSOLATION RESOURCE ASSESSMENT

This includes the modelling and measurement of broadband and spectral terrestrial solar radiation, evaluation of the validity and accuracy of the current SOLMET/ERSATZ insolation data bases; improvement of the understanding of small scale (1-100 km) variations in insolation caused by urban, coastal, and mountainous conditions (time integrated - day, month, and year); and development instrumentation for monitoring both spectral and broadband solar radiation.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

B. MEASUREMENTS AND CHARACTERIZATION

This includes Government maintained facilities for developing and performing specialized measurements and characterization which are unique to the PV Program and community requirements such as standardized efficiency measurements, electrical and material composition characterization, cell and module performance, stability and accelerated lifetime tests, and operational tests under well defined conditions.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

C. FLAT PLATE MODULE RESEARCH

This effort will include research for incorporating advanced photovoltaic components and processing techniques into module designs to maximize efficiency, as well as durability and reliability. This work will incorporate statistics of field failures, along with advancements in understanding of failure modes.

Contribution to Basic Scientific Understanding	Very likely		Likely	Not likely	
Potential Impact on Further Technology Development by Private Industry	Excellent	Probable		Unlikely	
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

D. CONCENTRATOR MODULE RESEARCH

Research will be continued for an effective integration of concentrator components including concentrator solar cells, optical concentrators, and receivers to achieve high efficiency, durable modules. Of particular importance are the encapsulant material properties and the interface interactions associated with the concentrator modules. The subject of the research includes polymer encapsulants, ceramic spacers, grooved cover glass, secondary optics, and methods of integration. Potential utilization of thermal energy will also be investigated to achieve high overall conversion efficiency.

Contribution to Basic Scientific Understanding	Very likely		Likely	Not likely	
Potential Impact on Further Technology Development by Private Industry	Excellent	Probable		Unlikely	
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

E. ADVANCED PHOTOVOLTAIC SYSTEMS RESEARCH

Investigate the system interaction and adaptation required of advanced PV cells and devices using theoretical analysis, simulation, and experimental verification in order to provide understanding of the technical issues which influence material/device research and which may impact the ultimate utilization of these devices. This research will address the technical interrelationships of photovoltaic systems and their potential loads with respect to advanced photovoltaic devices.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent		Probable		Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

F. METALLIZATION RESEARCH

Advanced research will be continued on the investigation and development of new metallization processes. It will include metallization processes such as formation of silicides (which are electrically conductive while forming barriers to the low temperature diffusion of metals used as solar cell contacts) and selection of appropriate metals for new front contact finger design. Metal contact corrosion and corrosion physics will be investigated. Study of metallization characteristics unique to concentrators are also included.

Contribution to Basic Scientific Understanding	Very likely		Likely		Not likely
Potential Impact on Further Technology Development by Private Industry	Excellent	Probable			Unlikely
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

G. FRESNEL LENS RESEARCH

Research on both point focus and linear focus Fresnel lenses, which have already been identified as effective concentrators, is included to further improve material and optical properties. This research also includes domes lenses, laminated high concentration lenses, computerized lens design optimization, and accurate evaluation of solar flux profiles.

Contribution to Basic Scientific Understanding	Very likely		Likely	Not likely	
Potential Impact on Further Technology Development by Private Industry	Excellent	Probable		Unlikely	
Priority for Federal AR&D	Very high	High	Medium	Low	Lowest

Comments:

ELECTRIC POWER RESEARCH INSTITUTE

EPRI

March 11, 1982

The Honorable Don Fuqua, Chairman
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Fuqua:

In response to your invitation of February 9, 1982, and in accordance with my letter to you of March 4, 1982, enclosed is outside written testimony I am submitting for your 16 March 1982 Hearing of the Subcommittee on Energy Development and Applications.

Also enclosed is the December 1981 issue of the EPRI Journal, which provides supporting information for my testimony. I ask that this Journal issue be included in the hearing as a part of this written testimony.

I appreciate this opportunity to express my views, and would be happy to discuss my submission with you or your staff at your pleasure.

Sincerely,

E. A. DeMeo

Edgar A. DeMeo
Manager
Solar Power Systems Program

EAD:cf

Enclosures (2)

cc: E. Frankel

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DR. EDGAR A. DE MEO

Dr. Edgar DeMeo is the Program Manager, Solar Power Systems Program, Advanced Power Systems Division, of the Electric Power Research Institute (EPRI), Palo Alto, California. He assumed this position in January of 1980.

Dr. DeMeo joined EPRI in 1976 as a Project Manager for photovoltaics and wind energy. Prior to this, he was with Brown University, Providence, R.I., most recently as Associate Professor of Engineering (Research). While a Lieutenant in the U.S. Naval Reserve from 1967 to 1969, Dr. DeMeo was an Officer Instructor in the Science Department at the U.S. Naval Academy.

During the summer of 1974, while on the Brown University faculty, Dr. DeMeo participated in planning EPRI's Solar Program. Subsequently, he carried out an assessment of thin film photovoltaic technology for EPRI. His research interests have included micro-wave devices, magnetic materials, infrared spectroscopy and photovoltaics.

Originally from Yonkers, N.Y., Dr. DeMeo received the BEE degree from Rensselaer Polytechnic Institute in 1963 and the Sc.M. and Ph.D. degrees in Engineering in 1965 and 1968, respectively, from Brown University.

December 1980

OUTSIDE WRITTEN TESTIMONY

DR. EDGAR A. DEMEO, MANAGER, SOLAR POWER SYSTEMS PROGRAM

Electric Power Research Institute

Palo Alto, California 94303

INTRODUCTION

Since their inception in the early 1970's, the federal research and development programs in solar and wind power have expended over one billion dollars of public funds. These programs have been of value to the electric utility industry for two primary reasons. First, they may have potential for broadening the range of electricity generating options which offer relief from premium fuels consumption. Second, through the successful exercise of the research and development selection process, these programs have provided a firm basis for the choice of a few solar technologies warranting continued effort with public funds, from the menu of more than a dozen technologies that have received serious attention. The following comments reflect my personal views on prospects and programs for three promising solar-electric technologies: large wind turbines, solar thermal central receiver systems, and photovoltaics.

Budget cutting, if carefully exercised, can be a healthy process. Activities with lesser potential can be pared, while those showing promise can be maintained. To a degree, this process is occurring in the solar electric budget transition from 1982 to 1983. However, in my view, for two of the technologies which show the greatest promise based on actual performance to date, large wind turbines and solar thermal central receivers, the extensive budget reductions and associated program redirections currently indicated for FY 1983 may preclude effective technology transfer to the private sector. There is serious danger

that sound, federal investments in these two technologies that have totaled several hundred million dollars may be rendered useless for their intended purpose of advancing new, worthy technologies.

In recognition of the extensive shift in federal research and development strategy in the solar electric technologies, the Electric Power Research Institute (EPRI), as the research arm of the United States electric utility industry, is currently reexamining its roles and activities in solar and wind power. These reexaminations have included a major, in-depth evaluation of wind power technology status and prospects that has been carried out over the past several months by a panel of experts. While EPRI may be able to accommodate some adjustments within its research and development efforts, it is clear that EPRI and the electric utility industry are not in a position to fill the gap created by the proposed reductions in federal solar-electric programs.

In the following discussion, arranged by technology, the views I express reflect our aggregated experience from involvement in utility-oriented solar electric programs over the past eight years; and, in addition, the activities reexaminations currently underway. As background support for these comments, I submit the enclosed December 1981 EPRI Journal, which presents our positions on the major solar and wind technologies. I ask that this Journal issue be included in the hearing record as a part of this written testimony.

95-882 O—82——72

WIND POWER

The federal wind program has, in my view, been soundly formulated as a logical research and development effort, and has been well managed. In particular, the large wind turbine program, under the technical management of NASA's Lewis Research Center, has progressed on an orderly path from early research activities to current generation machines which are tantalizingly close to commercial availability. Of all the solar electric technologies under development, large wind turbines are closest to a full understanding of potential in electric utility applications.

Performance Evaluation

A crucial step in the evolution of this full understanding is now in grave danger. The operation of premier test programs is not addressed in the FY 1983 federal wind budget. These tests, including one currently underway at Goodnoe Hills, Washington, and another planned for summer 1982 initiation at Medicine Bow, Wyoming, are essential to:

- realize the benefit of the extensive federal investment to date
- quantify and evaluate the performance of state-of-the-art wind turbines
- identify further research and development needs
- develop user (primarily electric utility) confidence in this new power technology.

The research and development efforts leading to these test programs have utilized nearly $100 million of public funds. Execution of these test programs can probably be carried out for some $10 million. Hence,

one incremental dollar for every ten dollars already expended can allow the quantification and evaluation of the actual benefits accruing from the research and development effort. Alternatively, refusal to spend the incremental dollar will very greatly reduce the value of the ten dollar investment. It cannot be overemphasized that lack of user confidence will preclude private sector assumption of the risk for further development and commercialization of this technology.

NASA Lewis Involvement

One other key product of the federal investment in wind power is likely to be lost as a result of the indicated FY 1983 budget cuts. A center of excellence and body of knowledge in large wind turbine technology has been established over the past decade at NASA's Lewis Research Center Wind Energy Project Office. In addition to managing the federally-sponsored activities in large wind turbine development within the industrial sector, this Office has conducted extensive, in-house, supporting research and technology development activity. Equally important, it has interacted intimately with several corporate members of the current wind turbine development community whose primary financial support has been internal rather than federal. One of these firms is now a major contender in this fledgling industry. By sharing its experience with these organizations and, in turn, learning from them, the Wind Energy Project Office has provided and can continue to provide an excellent example of the transfer of technology, developed at public expense, to the private sector. It is my understanding that this Office will be phasing out of wind power technology

during FY 1983 under the current budget scenario, and will not participate in wind beyond 1983. Thus, at a time when private industry, currently testing the waters in the wind power business, could benefit most from the assistance of an available source of knowledge in wind power technology, this publicly-funded Office will be eliminated. While I recognize this phase-out stems from NASA policy shifts as much as from the DOE budget reductions, I believe this loss will be one of the saddest results of the current shift in Administration research and development strategy for solar electric power.

MOD-5 Program

The current generation of wind turbines, typified by the MOD-2 machine, is not yet cost-competitive for widespread electric utility application. Accordingly, the federal wind program is conducting a development program for an advanced generation wind turbine, called the MOD-5. Continuation of this program would almost certainly contribute significantly to large wind turbine development.

The above-mentioned EPRI wind power technology evaluation indicated two avenues with significant potential for developing cost-effective wind turbines. One would entail the upgrading of current generation machines through an orderly series of engineering improvements. The second would involve the design and development of a new generation of larger, more advanced machines such as the MOD-5 units. An important advantage of the second avenue would be a more effective basis for the continued involvement of the NASA Lewis team, coupled with enhanced prospects for broadening wind power's industrial base in the private sector.

Nevertheless, the MOD-5 activity should not be undertaken at the expense of adequate performance evaluation from the existing large wind turbine installations.

SOLAR THERMAL CENTRAL RECEIVER SYSTEMS

The federal program in solar thermal energy systems has funded extensive activities in three primary solar thermal conversion approaches: central receiver systems, point-focus parabolic dish systems, and linear focus parabolic trough systems. It is becoming clear that trough systems, because of relatively high thermal losses and limitations on achievable temperatures, will not be economic for electricity generation by utilities. For dish systems, very little performance and operating information is available, so the potential of these systems for application by electric utilities is highly uncertain.

In contrast, the central receiver program has come a long way down an orderly research and development path over the past decade. Four central receiver concepts have been thoroughly tested at the Department of Energy's Central Receiver Test Facility, and results to date have been encouraging. In addition, results from three, independent, corroborating cost estimating exercises indicate that prices for sun-tracking heliostats, the major cost element in a central receiver power plant, can be economically attractive in large quantity production. No insurmountable technical barrier to successful development of central receiver systems has been

identified. To bring the development program to its rightful conclusion, what remains is to operate and evaluate complete systems at a scale which is meaningful to the electric utility industry.

Performance Evaluation

One of the successfully tested central receiver concepts forms the basis for the Solar One Experimental Pilot Plant, scheduled for initial operation at its southern California site within the next several months. This pilot plant is the culmination of federal expenditures to date in the development of central receiver systems; and, barring unforeseen problems, will become the premier solar central receiver experiment in the world.

The paramount requirement on the federal solar thermal energy program over the next two years and beyond is to ensure that the Solar One experiment is carried through to a logical, thoroughly understood conclusion. Success in this activity will require (a) completion of the plant's construction, (b) extensive operation coupled with thorough evaluation of the plant's performance and operating requirements, and (c) dissemination of test data and operating experience to all interested parties. In defining the remainder of the Solar One program, the overall aim must be to maximize the benefit to the country of the extensive public expenditure to date, rather than to seek an expedient path for completing the experiment at minimum incremental cost. This point cannot be overemphasized. The outcome of the Solar One experience will have far greater bearing on any subsequent initiatives in solar thermal central receiver systems than any other single activity.

In recognition of the overriding need to support activities in present generation central receiver systems as typified by Solar One, EPRI has recently discontinued a complementary program for development of an advanced central receiver concept. These EPRI efforts will be redirected in part to aid in the performance evaluation and experience documentation for Solar One and other existing field test installations. But properly planned and executed test programs are expensive. EPRI and the electric utility industry cannot carry them out alone. The federal program has a primary responsibility to play the leading role in carrying experiments like Solar One to fruition.

Again, as with large wind turbines, the benefits of ten dollars expended for research and development can be quantified for approximately one additional dollar. But without this incremental expenditure, the value of the development effort will never be well-understood.

Pre-Commercial Pilot Plant

Even if Solar One is a complete success, solar thermal central receiver systems cannot be declared ready for commercial application. Commercial central receiver power plants would probably be several times larger than Solar One and would employ key component improvements that have been developed in parallel with the design and construction of Solar One. Utilities and manufacturers will not make the transition from Solar One to commercial commitments in one step. At least one intermediate step, a pre-commercial pilot plant, will be required. This plant could be either a solar-repowered conventional power plant, or a stand-alone solar

plant, several times larger than Solar One and requiring a total of at least $100 million over four or five years. In my view, the technical and economic risks associated with this plant will be too great for industry and utilities to underwrite by themselves. Hence, in order to proceed, continued cooperation among the federal government, industry, and utilities will be required.

PHOTOVOLTAICS

Photovoltaic conversion maintains an innate appeal among solar electric conversion approaches because of potential simplicity in photovoltaic power systems. The primary conversion of solar energy to electricity occurs in a solid state electronic device with no moving parts. If photovoltaic research programs are successful, this technology could well offer the greatest potential of all the solar electric technologies.

Photovoltaic systems may prove to be useful over a wide range of applications, but recent EPRI studies indicate that by far the greatest promise for significant energy contributions from photovoltaics rests with electric utility applications. Up to now, however, no photovoltaic devices have been developed which will allow the realization of photovoltaic power systems that are economically attractive for electric-utility-scale power generation. While the technological status has been consistently oversold, the fact remains that photovoltaics currently resides at the research end of the research and development spectrum.

Economic and Technical Requirements

Recent EPRI analyses of the value of photovoltaics in electric utility applications indicate that flat plate photovoltaic systems for use with no sunlight concentration will require photovoltaic module conversion efficiencies of 15% or greater, with module costs under $100 per square meter. As a point of reference, today's module costs are higher by a factor of 10 or more, and efficiencies are at best 10%. On the other hand, systems employing high levels of sunlight concentration (nominally 500 times) will require photovoltaic cell conversion efficiencies of 25% or greater; but, because of greatly reduced required cell areas, can allow cell costs approaching $10,000 per square meter. These costs are comparable on a unit area basis to production costs for today's sophisticated electronic integrated circuits, and the efficiencies appear to be achievable.

Federal Program Emphasis

Over the past eight years, the primary emphasis of the federal photovoltaics program has been cost reduction of flat plate single crstal silicon cells and cell modules through technological extension and automation of production techniques rooted in spacecraft solar cell fabrication. I believe that single crystal silicon flat plate modules, owing to fundamental raw material requirements and to conversion efficiency limitations in high volume production, are not likely to achieve cost goals required for economic attractiveness in utility applications. However, these modules do enjoy a small commercial market today for specialized, remote power applications where utility electricity is not readily accessible.

More recently, federal program attention has increased for alternative photovoltaic devices such as thin film cells and high efficiency, high concentration cells. In my view, these approaches, still in the basic research stage, hold far greater promise for bulk power applications than single crystal silicon efforts and should become the primary emphasis of the federal program.

Recent progress with high efficiency, high concentration cells, coupled with the realization that these cells need be no more complex and, therefore, no more costly than today's integrated circuits, strongly suggests that high concentration systems show the most promise of all photovoltaic approaches.

Long-Term Commitment

Although success for photovoltaics can by no means be assured, realization of this technology's potential can come only with a long-term commitment to relevant basic research programs over a period of five to ten years or more. These programs need to address fundamental physical, chemical and electronic issues in thir film materials and high quality crystalline materials. Resolution of these issues may allow the development of sophisticated, new photovoltaic devices whose ultimate cost and performance levels can become attractive.

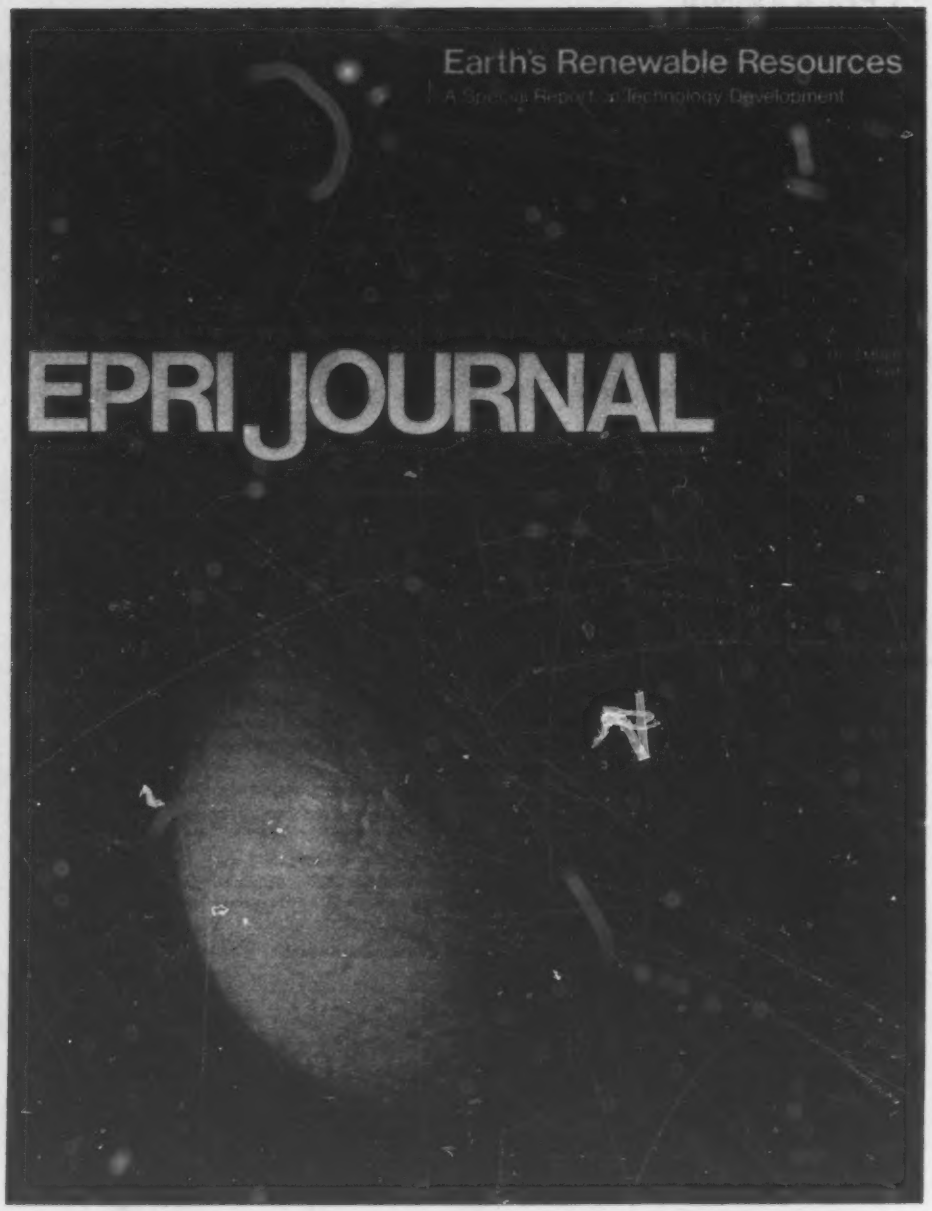
Such a long term program would benefit from a focal point for coordination of efforts at laboratories throughout the country, as well as for the conduct of key, long-range elements of the work. The Solar Energy Research Institute could serve in the national interest as this focal point.

SUMMARY

The federal research and development programs in solar-electric technologies have made significant progress over the past decade. The prospects for a number of these technologies have become much better understood over the past several years, and a few can now be selected for continued, serious attention with public and private funds.

Despite progress to date, the development job is not complete. Major field testing and performance evaluation activities must be carried out with existing federally-funded installations of large wind turbine and solar thermal central receiver systems, in order to evaluate the benefits of the considerable federal investment to date. For continued progress in these two solar-electric alternatives, additional technology advancement and pilot plant activities are necessary. For photovoltaics, a thorough understanding of prospects awaits new results from the research laboratory.

If research and development programs in these promising solar-electric technologies are to achieve fruition, I believe continued, significant federal participation is necessary. With technical risks that are still high, and with the present, stressed financial conditions faced by manufacturers and utilities, the private sector is not in a position to fill the gap that would be created by the proposed federal budget cuts.


Earth's Renewable Resources
A Special Report on Technology Development
EPRI JOURNAL

EPRI JOURNAL

Volume 6, Number 10 December 1981

Editorial	2	**Taking Stock of Renewables**
Overview	6	**Renewable Resources: Development at the Crossroads** After a decade of popular and political support for renewable resource technologies, the new administration is turning the development job back to the private sector.
Features	12	**SHAC: A Nation Turns to the Sun** Solar heating and cooling includes a number of different technologies for displacement of energy. Some will make it and some won't.
	18	**Geothermal: New Potential Underground** New technologies for turning hot water from the earth to productive use could mean a rapid expansion of geothermal power over the next 20 years.
	26	**Wind: Prototypes on the Landscape** Large wind turbines are being readied for eventual mass production and clustered operation. The next few years should determine their future for utility markets.
	36	**Solar-Thermal Electric: Focal Point for the Desert Sun** Power tower pilot plants, being researched in several countries, may become competitive with oil- and gas-fired plants in the American Southwest.
	44	**Photovoltaics: A Question of Efficiency** Remote applications can justify photovoltaic electricity today. But where there is access to conventional power generation, lower costs and improved efficiencies for solar cells and systems are needed.
	54	**Sea, Soil, Sky: Testing Solar's Limits** OTEC, biomass options, and synchronous satellites have captured conceptual fancy, but the facts emerging from engineering assessment point to lower priority among the R&D options.
	62	**Fusion: From Science to Engineering** Fusion could eventually eliminate problems of fuel scarcity, but the monumental engineering challenges ahead place realization of this potential at least 40 years in the future.
	71	**Washington Report: Policy Impact** Informed observers offer opinions on the future for renewables, given the turn in federal policy.
Briefs	10	**Timetable of Renewable Energy Technologies**
	31	**The Land Use Question**
	35	**Integrating Renewables Into Utility Networks**
	52	**Utility Solar Survey**
	53	**Squeezing More From Hydroelectric Power**

Taking Stock of Renewables

What happened to the energy crisis? A short time ago, reliance on oil resources for the nation's energy security was seen by the government and the public as an inadequate solution to a steadily growing problem. Replacement of gaseous and liquid fossil fuels by renewable energy resources became a significant element in an urgent drive for energy self-sufficiency, a goal fostered by a new respect for the dynamics of world energy supply.

Yet in the past year, the new administration has done an about-face, shifting emphasis from the further development of oil-displacing energy technologies to a reliance on increased oil exploration and production. Federal R&D funds earmarked for aiding the commercialization of energy options that could begin to impact our energy supply systems in the early 1990s have been cut drastically, leaving support for mainly high-risk, high-payoff research.

Is the new government direction solving our energy supply problems or merely postponing them? Almost certainly the latter. Gaseous and liquid fossil fuels still represent a finite resource pool, no matter how much we manage to squeeze what is left. The energy crisis is not gone, just submerged in the face of temporarily reduced demand, masked in part by the current recession and the administration's preoccupation with the present state of the economy and budget-balancing exercises. When energy supply problems do reappear, the consequences most probably will be even worse than before—the shortages that startled us in 1972 and 1974 are likely to bite us next time around.

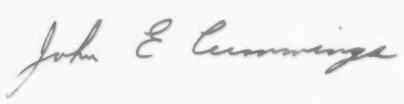
How do renewables fit with the new federal direction? The policy shift forces us to take stock. Fortunately, the course of the 1970s has left us a valuable legacy of perspective and understanding. That decade saw the emergence of an energy ethic in this country, featuring conservation and more efficient use of resources. The awareness of consumption on the personal level has grown in the home and on the highways; this will surely continue. Awareness on the national level not only spurred the search for new energy technology options but also led to the acceptance of using a mix of options for satisfying national energy demand.

The search for new energy options, especially for renewables, turned up a great number of ideas for the mix. When subjected to the rigorous analytic machinery of the R&D process, many were found not to be technically feasible, and of those that

were, few are expected to eventually become economical for commercial use. Further, compared with conventional generation technologies, none of the renewable resource technologies identified as good prospects are expected to provide a large fraction of needed power, with the possible exception of fusion, which could have a strong impact sometime in the next century. Nevertheless, in the context of an energy mix, an option does not have to represent a large fraction of the energy supply sector to make a meaningful contribution. Indeed, the regional and local impacts of wind, hot water geothermal, and solar-thermal conversion could be considerable.

R&D on these three particular applications has proceeded to an advanced stage, and it is expected that if momentum can be maintained, their commercial potential will be determined within the next several years. However, it is at this point—the demonstration stage—that funding is most critical. With government emphasis shifting away from commercialization of technologies, there is considerable uncertainty about whether these energy options can make the final all-important step that will bring them firmly into the commercial sphere.

It remains to be seen whether other interested parties—users, manufacturers, or suppliers—will underwrite that portion of the risk necessary to bring geothermal, wind, and solar-thermal applications through the critical demonstration stage. The nation as a whole faces a high risk in failing to follow through on such applications, not only in terms of losing the payoff on a large R&D investment but also in terms of losing the availability of precious resources. The assessments and the initial phases of technology development have been done. These technologies represent the best hope for use of renewable resources in the early 1990s—technologies we need to demonstrate now at commercial scale in anticipation of the energy crisis that is certain to return.



John E. Cummings, Director
Renewable Resource Systems Department
Advanced Power Systems Division

Authors and Articles

Last year the *EPRI Journal* conducted a random-sample survey of its 30,000 subscribers to elicit opinions on the magazine's editorial policy and to gather suggestions for its future. Part of the questionnaire invited readers to supply topics they would like to see covered in upcoming issues. By a large margin, renewable energy sources was the subject most frequently mentioned.

This special issue was created to respond to such widespread interest. The *EPRI Journal* staff, augmented by personnel from EPRI's Public Information Department and Washington Office, put together this update on renewables by drawing [illegible] expertise of the Renewable Resources Department of the Advanced Power Systems Division. Technical contributions were also made by EPRI's Energy Management and Utilization Division.

John Cummings is director of the Renewable Resource Systems Department in EPRI's Advanced Power Systems Division. Before joining EPRI in January 1975, he was director of energy programs for Itek Corp., concentrating on strategies to commercialize solar-thermal and photovoltaic energy conversion processes. Earlier he undertook resource recovery analyses for the Atomic Energy Commission, including definition of an AEC-sponsored solar program. He holds a BS in engineering from the U.S. Coast Guard Academy and an MS and a PhD in physics, in addition to an MBA, from the University of Arizona.

John Bigger, who manages solar-thermal conversion research projects, was previously with the Los Angeles Department of Water & Power, one of two California utilities now funding the design and construction of the industry's first solar-thermal plant. Following his graduation from Iowa State University with a BSEE in 1965, Bigger spent 10 years with the Los Angeles utility in transmission design and construction and in resource planning, with special emphasis on waste heat, geothermal, and solar energy. Bigger joined the EPRI staff in May 1976.

Kenneth Billman is project manager for inertial confinement fusion. Before joining EPRI in 1979, Billman spent nine years at NASA's Ames Research Center, Sunnyvale, California, most recently as advanced-projects group leader in the Materials and Physical Sciences Branch. From 1967 to 1970 Billman worked at NASA's Electronics Research Center, Cambridge, Massachusetts, as staff physicist, Optical Physics Branch. He was assistant professor of physics at the Massachusetts Institute of Technology from 1961 to 1967 and an instructor in physics from 1959 to 1961. He earned his BA in physics from Thomas More College and his MS and PhD in physics from the University of Cincinnati.

Edgar D. Meo is manager of the Solar Power Systems Program. He began his EPRI work as a consultant in advanced systems, having previously taught at Brown University for six years and in the Naval Academy's science department for two years. He graduated in electrical engineering from Rensselaer Polytechnic Institute in 1963, then earned an MS and a PhD in engineering from Brown University, where his research specialty became solid-state materials.

F. R. Goodman, Jr., who manages projects on wind power, came to EPRI from the Los Angeles Department of Water & Power, where he was responsible for assessing solar energy as a resource for heating and cooling, electric power production, and alternative utility applications. In this connection, he had experience in design engineering, system planning, and thermal resource development. Goodman holds a BS, an MS, and a PhD in electrical engineering from the University of California at Santa Barbara.

Arvo Lannus is program manager for residential and commercial applications in EPRI's Energy Utilization and Conservation Technology Department. Before joining EPRI in May 1980, Lannus was director of advanced energy technology at Gordian Associates, Inc., where he managed research and consulting activities in energy-efficient equipment and practices. Earlier, he was an assistant professor of chemical engineering at Cooper Union School of Engineering in New York. Lannus has a BS in chemistry and a PhD in chemical engineering, both from Drexel University, Philadelphia.

95-882 O—82——73

Gary Purcell is project manager for solar heating and cooling in the Energy Utilization and Conservation Technology Department. Previously, he was a senior thermodynamics engineer at Lockheed Missiles & Space Co. Purcell earned his BS in mechanical engineering at Oklahoma State University.

Vasel Roberts is manager of the Geothermal Power Systems Program. His major areas of interest include the earth sciences, energy recovery, process development, power conversion, and environmental implications associated with geothermal development. Before joining EPRI in 1975, Roberts worked as deputy manager for public safety systems at the Jet Propulsion Laboratory, Pasadena, from 1967 to 1975. Earlier, he was with Sperry Rand Corp., working in systems development and related research. He received a BS in mechanical engineering from the University of New Mexico.

Roger Taylor is a project manager in the Solar Power Systems Program. Before joining EPRI in July 1980, he spent two years at the Solar Energy Research Institute, where he was concerned with the integration of solar power technologies and electric utilities. The two years prior to that Taylor spent with the Arizona Public Service Co., where he was involved with solar/utility issues in the research department. He holds a BS in physics from Colorado College and an MS in mechanical engineering from the University of Arizona.

OVERVIEW

Renewable Resources: Development at the Crossroads

Renewable energy resources are those that draw on the natural energy flows of the earth, such as the wind, the sun, the rise and fall of water, and the venting of the earth's core heat.

For millennia they were the predominant energy forms of man's enterprise and survival. They were dispersed as broadly as sunshine and plant life, seemingly inexhaustible, and free for the taking. And then civilization discovered the fossil fuels, those compressed layers and pockets of ancient plant life, and the revolution of industry was on. Energy density was the key.

The new fossil resources and the technologies to exploit them became intimately tied. Coal spurred rapid advances in the steam engine and its nineteenth-century progeny of locomotives, steamboats, and shaft-driven automation. Metallurgically, it transformed iron to steel, opening the door to better boilers, skyscraping structures, and lighter, more resilient machines. And in turn, these new machines, now capable of containing (or internalizing) combustion, stood poised to exploit the newly discovered fluid fuels derived from oil. Cars, planes, tanks, and trucks roared forth into the twentieth century, utterly transforming the societies that created them. And with the exception of hydro power, the diffuse and difficult-to-collect renewable energy sources were left behind like so much dust, seemingly forever.

On a geologic time scale of hundreds of millions of years the fossil fuels are also renewable; but for all practical purposes, which is to say on a contemporary time scale of centuries, they are fixed and finite. It is this simple fact that seemed to strike home with such great urgency in the early 1970s, when domestic oil production peaked and foreign suppliers gathered together to protect their diminishing hoards and to control production and price. The great mistake was realized. The accelerating rush of the industrialized nations into overwhelming dependency on oil could not be sustained. Prices soared, closing the brief era of cheap energy and opening the era of alternatives.

The era opened with some confusion. Alternatives came to mean different things to different people. To some, light water reactor technology was an alternative, at least to fossil fuels, and one whose fuel supply could be stretched indefinitely by breeder technology. To others, alternatives precluded all established forms of energy supply and institutions and concentrated instead on the means of achieving decentralized social structures. Still others thought of alternatives as synonymous with renewable energy resources or limited the term exclusively to solar. In the squabbles that followed, nearly everyone ignored the obvious: that each of the terms is just a handy grab bag for a large number of very dissimilar technologies, each with a different pathway and timetable of development. At a minimum, solar encompasses a half-dozen major technical variations (water heating, space heating, space cooling, solar-thermal electric, photovoltaic, and wind); geothermal includes three (steam, direct flash, binary cycle); and fusion, two (magnetic confinement, inertial confinement). Beyond this there are dozens of important distinctions. Because of the apple-orange dilemma of these collective terms, experts and laymen couldn't agree on the truth of any general statement. Were renewables here and now? Were they economic? Yes and no. Some were, some weren't. Both sides found themselves right—at least upon qualification.

More fundamentally, the era of alternatives also brought about a broad search for technological solutions. Security seemed to lie in the diversity and

independence of supply. And American ingenuity was stirred by the competitive opportunities unfolding with each new ratchet in the world price for oil. Energy resources that had previously made no economic sense suddenly looked inviting. Older, discarded technologies, ranging from synfuels to windmills, were reexamined; existing coal and nuclear technologies were assigned higher priorities and a greater role in the national plans; and such new technologies as fusion and photovoltaics were prodded forward with new intensity.

But among all the alternatives that poured forth, serious and whimsical, it was the renewable resources, particularly solar, that fired the American imagination. They seemed to make sense—common sense, if not yet engineering and economic sense. They seemed more understandable and everlasting, free and clean, and somehow more in concert with nature and current philosophical fashion. Besides, they were, almost by definition, the inevitable heirs to those depletable (and dirty) fossil fuels—and if so, why wait, went the dialectic.

Rivalries set in, as advocates for specific technologies emerged. Most overstated their cases, feeding public confusion about the true nature and scale of America's energy problem. Energy options were thus relegated to a popularity contest; and pollsters took the pulse of preference, annually proclaiming solar at the top of the technonogical hit parade. Serious studies by different groups, with widely varying assumptions, contested the renewables' potential contribution to national energy use; estimates of solar alone ranged from 1% to 25% by the year 2000. Those on the low side said it was a question of economics and the pace of technical development and deployment; those on the high side said it was a question of national willpower.

In the public debates over the potential contribution of renewables in general and solar in particular, percentage points were tossed about with casual abandon, reflecting an inability to grasp the full measure of the target, the immensity of the American energy production and consumption system. For the sake of illustration, by the year 2000 annual U.S. energy consumption will be roughly equivalent to the present oil reserves of Alaska's North Slope, and a single percentage point will be roughly equivalent to one quadrillion Btu. In terms of renewables, displacement of a single quadrillion represents the installation of about 20,000 large wind turbines (2.5 MW per machine) or about 400 solar-thermal power tower systems of 100 MW each (15 times the current system near Barstow, California) or about 1000 average hydrothermal sites of 50 MW each. Following the massive CONAES study, Philip Handler, president of the National Academy of Sciences, summed up the problem of perception by saying, "It's very difficult to get your head wrapped around how large it [the U.S. energy supply] is, and until you do, it's easy to accept glib solutions, to think you have an easy solar energy solution, or a geothermal answer, or an idea that we'll just build windmills. What you have to get your head around is what 30 million barrels a day of petroleum really means or what 100 million tons of coal is really like. And until you do, you can't learn to deal with these questions realistically."

Politics and the energy ethic

The only thing that everyone seemed to agree on was that the emerging renewable technologies couldn't stand alone. They would need public support to raise an industry and to compete adequately in the private sector.

Political support for the renewables gathered momentum throughout the 1970s. Federal funding for R&D of solar, geothermal, and fusion climbed several times faster than OPEC oil prices, accelerating from a few million dollars in 1973 to nearly $1.5 billion in fiscal year 1981. Major emphasis was put on bringing new applications of renewable resources into the marketplace. Efforts to assist commercialization ranged from programs to develop large wind turbines and central receiver solar-thermal systems (power towers) to subsidies for residential conservation to tax incentives for the installation of solar or other renewable hardware in the home or business. State governments followed suit with similar tax incentives. Total direct and indirect public support for the renewables was over a billion dollars per year by the end of the decade. And pri-

vate support was on top of this.

In several respects, the 1970s also became a decade of preparation for the energy transition ahead. A significant industrial R&D capability was established, largely through government financial support and policy emphasis. Nearly 10 years of national preoccupation with energy had slowly led to public awareness and appreciation of the pervasiveness of the energy issue, and a begrudging acceptance of the inability of the nation's technological community to bring about a quick fix. The so-called energy crisis was being seen in a clearer light; the shortage was not a shortage of energy but rather a shortage of cheap oil, nearly half of which was fueling a monstrous fleet of inefficient automobiles. Progressively, people settled in for the long haul, and as energy expense filtered through every fiber of economic life, an energy ethic emerged, one that fostered conservation and improved efficiency. Industry and consumers alike found ways to cut back or substitute or recapture. By the end of the decade conservation efforts appeared to have made a significant dent in oil imports, although the recession fuzzed the claims. After reaching a peak of nearly 9 million barrels a day in 1977 (50% of U.S. oil consumption), imports dropped to about 5 million barrels a day (35% of U.S. oil consumption) by summer 1981.

Exploring the impact

But what of renewables? Where do they stand after a decade of development and evaluation? And what can they ultimately contribute? Enough has been learned through the comparative analytic framework of the R&D process so that the less promising technologies have now been culled from the pack, the seemingly endless stream of conceptual options. Technical feasibility has shaken out some, economics many more. And the pathways and pitfalls to commercial use are now much clearer.

At least for several decades, renewables will probably play only a small, supplementary role in the total U.S. energy system, although they could well become significant contributors on a local or regional level. They are likely to have almost no impact on the large transportation fuels market. Most are pointed at the electric utilities as the predominant, or at least initial, market. Wind, solar-thermal electric, and geothermal, among the most promising of the emerging technologies, are at least a decade away from commercial inroads and are now poised at critical stages in their development. Photovoltaics, with the exception of remote applications, is still further downstream; and fusion, which has just begun the awkward transition from science to engineering, is perhaps 20 to 40 years from commercial demonstration.

As a rough rule of thumb, it now seems that each of these emerging electric generating options—wind, geothermal, solar-thermal electric, and photovoltaics—has the potential for displacing on the order of a quadrillion Btu sometime into the early part of the twenty-first century. With the possible exception of geothermal, none will be competitive with baseload coal- and nuclear-generated electricity. They will be used primarily to displace premium fuels such as oil, and in the case of the intermittent technologies (such as wind and solar), will be given very little credit for displacing new generating capacity. The result is that most of these technologies will end up competing for the same small slice of oil-fired generation as many other emerging technologies, including load management technologies. All this tends to restrict commercial potential.

Overall, the diffuse nature of solar energy and the geographically restricted nature of geothermal energy will probably preclude them from ever becoming the predominant source of U.S. energy supply. Among the technologies treated in this issue, only fusion—with its unlimited supply of fuel—has the potential to radically transform the energy picture in the United States. And among the critical decisions to be made that will affect the fusion development path and its economics are whether the commercial devices will be large or small and whether they will be designed to produce electricity or to breed fuel for an existing fleet of fission reactors. The attempt in this issue is to explore the status and prospects of renewable energy technologies as well as fusion, an inexhaustible if not technically a renewable resource.

Critical juncture

This is a particularly appropriate time to step back and take stock because of the critical juncture that faces renewable energy research. First, energy R&D and energy independence have recently become lost in the fight against inflation and the lull created by a momentary glut of oil. Second, the Reagan administration is philosophically opposed to the role of government in the commercialization process—the progressive development and eventual demonstration of a given technology. It believes that commercialization is more properly the role of the private sector; that government should confine its support to long-term, high-risk research. Third, it appears that DOE may be in the process of being dismantled, its programs dispersed to other departments.

The upshot is that R&D budgets for renewables (excluding fusion) are being slashed to a fraction of their former levels, and major pilot plants and demonstration plants are in jeopardy. And it remains to be seen who will underwrite the risk in the developmental stages for each of these emerging technologies. Some, such as solar heating, are probably far enough along that withdrawal of federal funds for R&D would not in itself significantly affect commercial inroads, although removal of tax incentives would severely retard market development. Other technologies, such as wind and geothermal, which have progressed smoothly and rapidly in development and are now approaching critical demonstration phases, could lose momentum by the sudden withdrawal of federal R&D funds. In the case of wind power, for example, development of the MOD-5 horizontal-axis wind turbine is considered critical to expanding the potential commercial market. Still other technologies, such as ocean-thermal electric conversion and synchronous satellites, which pose enormous technical and economic hurdles, are given much lower priorities and are certain to die without federal R&D support.

Fusion stands in a category by itself, surviving on a stable budget and an extended timetable. Fusion has been cited as a prototype of the kind of high-risk research the new administration believes it should fund.

With the federal government apparently pulling out of many of the renewable energy applications, particularly the solar technologies, industry will be left to select options and carry on development and commercialization. Exactly how this will be done and by whom is unclear. The only thing that is clear is that a serious pruning is about to take place. Some technologies are going to be discarded and others effectively starved to death in a stretch-out of the funds so protracted that inflation eats up construction budgets. Only a few will prosper and those only if the private sector organizes to underwrite the risk of further development.

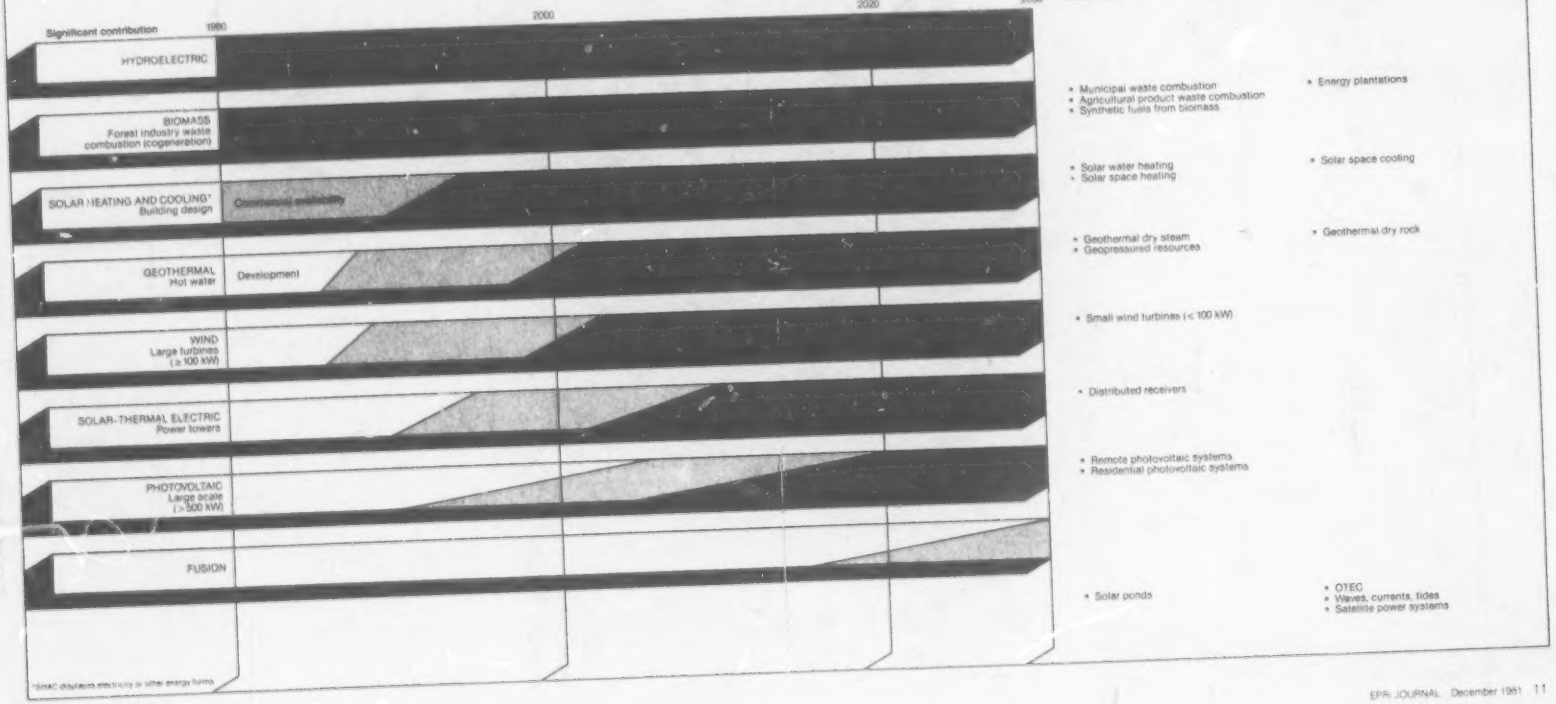
Teams will be required to pull together the expertise and financial resources of utilities, manufacturers, and venture capitalists—in some combination—to carry forward the critical steps to commercialization. Fortunately, the incentives for market development may be there. Many of these new technologies are inherently small and modular in nature, and they can be quite attractive to capital-strained utilities seeking incremental additions to capacity. Without such groups from the private sector to champion specific technologies, the commercial prospects are now in serious question.

At this juncture, somebody has to pick up the ball. No single institution can afford to carry the risk alone, and the larger issue before American industry is how to regroup its talents to exploit its new energy resources—solar and synfuels, fusion and fission, geothermal and shale. As with coal and oil before, technologies will have to evolve in a way that ensures compatibility with the resources at hand. In the end, it must be recognized that innovation, not energy, is the resource of fundamental concern—technical innovation, institutional innovation, and social innovation. For over 200 years, since the great clipper ships stole the seas, Yankee ingenuity has been a point of pride for Americans and, more important, our single greatest resource beyond political and economic freedom. ■

This article was written by Brent Barker, Editor, *EPRI Journal*. Technical background information was provided by John Cummings, Advanced Power Systems Division.

Timetable of Renewable Energy Technologies

Renewables include a wide variety of technologies, each with its own distinct timetable for engineering development and commercialization. Charted below are those technologies expected to become commercially available and eventually to make a significant contribution, defined here as equal to or greater than the equivalent of 1% of U.S. electricity generation. Listed separately are those technologies expected to make only a limited contribution—less than 1%; this list includes technologies whose impacts are likely to be felt only on a local or regional level. Also listed are some technologies that are not expected to become commercially available for reasons of economics or technical feasibility. Commercial availability refers to the point in time when a commercial system can be ordered. The pitched lines cover the uncertainty of the time estimates that divide the three phases.



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SHAC: A Nation Turns to the Sun

One of the first signs that the nation was moving toward renewables was the appearance of solar collectors on roofs across the country, gathering heat for swimming pools, domestic hot water, and interior space. A decade later, experience has confirmed what the experts expected: SHAC doesn't work in every situation, but in some applications it can work very well. The right SHAC system, applied in the right place at the right time, has the potential to lower utility costs and customer electricity bills. Researchers are identifying what those systems are—and where and when they work.

America's response to the increasing scarcity of energy resources began in the home. As the price of energy for residential space heating, hot water heating, and air conditioning went up, individual homeowners responded by conserving energy where they could. Thermostats were lowered, and insulation, weather stripping, and caulking were installed. Sweaters were pulled on, and down comforters purchased. These conservation measures are saving a considerable amount of energy, but only so much insulation and caulk, only so many cardigans and comforters can be applied to the problem; conservation is effective only up to a certain point. Beyond that, many homeowners look for renewable energy sources that have the potential to reduce fuel bills. They don't have to look far: the sun is shining just outside.

Today's applications

Solar energy for heating and cooling (SHAC) has been around for a long time in many forms. Technologies have been developed to use the sun for a range of residential and commercial purposes. With some solar collectors and minimal engineering, the sun can heat swimming pools and, in fact, is being widely used for that purpose throughout such states as California. With a bit more engineering, the sun can be used to heat domestic hot water; such systems are already economical in some areas of the country. Apply more hardware and more engineering, and the sun can heat interior space; this heat can even be stored for later use. Farther down the road, more difficult technical and economic issues might be resolved, and the sun could be used to cool interior space.

To many homeowners, solar seemed a welcome escape from mounting energy bills, and a large number of pool heaters, water heaters, and space-conditioning systems were enthusiastically installed in private homes. But as many enthusiasts found out, solar was not as free as it appeared at first, even despite the tax credits and other incentives that often came with it. True, solar swimming pool heaters were successful when they replaced costly natural gas heating, and solar domestic hot water heaters have also had a measure of success in certain areas. Yet solar space heating was economical in just a few places, and under certain economic conditions. Solar space cooling still appears to face formidable technical and economic hurdles.

As it turned out, the systems necessary to make the transition from sunlight to usable energy were costly; equipment was often improperly installed; breakdowns were frequent. Furthermore, most solar systems had to resort to backup energy—often electricity—at night or during cloudy days. When solar system owners turn to local utilities for energy, utilities require just as much generating equipment as if there were no solar systems at all. Widespread use of improperly designed solar systems could even result in higher electricity costs because of the expense required to keep generating equipment ready to provide large amounts of power to solar users during those periods of occasional demand.

However, solar still has the potential to lower utility costs and thus customer bills. A solar system equipped with thermal storage could store heat from the sun or from low-cost electricity generated during off-peak hours and use that energy during peak periods. In this way, solar systems could help smooth demand peaks.

Because of this potential for load leveling, SHAC systems are of interest to the utility industry, even though these systems generally belong to individual homeowners. But before full advantage can be taken of solar, specific systems must be defined and developed to meet customer energy needs at the lowest overall cost, including the cost of solar equipment and the cost of backup energy. These so-called preferred systems must take into account available fuels, weather conditions, and local patterns of energy demand. Through demonstration projects and studies, EPRI is trying to find those systems.

EPRI began its research into SHAC in 1975 by first studying active systems, according to EPRI Project Manager Gary Purcell. Active systems use the mechanics of collectors, piping, pumps, and fans to collect, store, and distribute the sun's energy. These systems were closest to commercialization and therefore likely to have the earliest widespread use. Although many active solar homes were being built (frequently as demonstration projects sponsored by individual utilities), they were often without adequate provision for acquiring and interpreting energy-use data. On behalf of the utility industry, EPRI took on the job of data collection and development of analytic methodologies that individual utilities could apply to their own particular situation in order to identify preferred SHAC systems.

In 1975 EPRI authorized Arthur D. Little, Inc. (ADL) to conduct a project that would help utilities and homeowners find preferred active systems for their service areas. The first phase of the project resulted in the development of an EPRI methodology for preferred solar systems (EMPSS), a computer program that examines residential solar heating and cooling options, analyzes their performance and impact on utility systems, and identifies the lowest-cost configurations, taking into account backup energy requirements.

EMPSS was tested with input data from 24 utilities, which included operating costs, electricity demand, fuel costs, and weather conditions in the different utility areas. Also factored into ADL's analysis was information on different residential characteristics, such as type of heating system, number of rooms, and heat transfer through walls. In all, more than 100 combinations of solar heating and cooling systems with electric backup were analyzed.

As the program was being developed, it became evident that there is no single "preferred" SHAC system. The best SHAC options vary considerably from region to region and from utility to utility, and each utility must run its own analyses to find the preferred system for its own region and utility characteristics. For example, application of EMPSS confirmed that demand is a cost factor that is often critical but varies widely. Demand costs reflect capital requirements for generation capacity, transmission and distribution, and other equipment that a utility must have available to meet peak power demands. Even though equipment may not be used often, its capital cost and upkeep add to customer bills, and it should be considered in the question of which, if any, solar systems are the lowest real-cost options for satisfying customer needs.

EMPSS has been available to utilities and in use for three years now. If economic factors change, such as fuel costs, time-of-day rates, or other costs, the model can be altered to accommodate them. Significant improvements in technology can also be factored in.

In the second phase of this SHAC project, 10 experimental houses were constructed—5 in Albuquerque, New Mexico, and 5 in Long Island, New York—to validate EMPSS on active solar heating and cooling system configurations and thus gain first-hand experience on real SHAC systems. The houses were used to provide data on how different SHAC systems performed in these two different parts of the country and how those systems would affect utilities and their customers if they were widely used. The style of the houses was typical of that of

Active SHAC systems use mechanical devices to collect, store, and distribute the sun's energy. The main components of an active system include solar collectors, pipes, pumps, and fans.

other houses in each area. Every home had its own computerized monitoring and data-gathering system, which recorded fluid temperatures and flow rates throughout the system, daily sunshine, equipment performance, and energy use. Each home was tested in a wide variety of modes.

Data collection at the 10 homes concluded early this year. Detailed evaluation of the results is still under way, but some significant conclusions have become evident. For instance, where studies of the solar hot water heating systems in both Albuquerque and Long Island used storage tanks for load leveling, it was found that the tanks' thermal losses were a dominant economic factor when storage was used for load management. This was true whether solar energy or off-peak power was being stored. Single-tank water heaters showed lower standby losses for the same volume than double-tank designs because of the reduced surface area in single-tank heaters. These tests seem to indicate that the effects of conversion, standby, and system losses more than offset the gains from off-peak price differentials. Conversion and storage of solar energy for later use does not currently seem economical when compared with available alternatives.

Other results confirmed that careful system sizing is important. Frequently, when space heating and domestic hot water systems were combined in these experiments, the hot water load tended to use up most of the solar energy, leaving little for space heating. So unless a SHAC system user is willing to carefully manage hot water consumption, more generous sizing or independent hot water and space heating systems might be desirable.

Other interesting results were that SHAC systems equipped with air collectors amassed more thermal energy than systems equipped with liquid collectors of equivalent size. Liquid thermal storage tanks were more efficient at storing energy than rock-bed storage systems. And underground tanks had heat losses virtually identical to those of aboveground tanks. A final report on the project, due early next year, will contain detailed performance comparisons.

EPRI's project on residential SHAC was followed in 1980 by a complementary project on commercial SHAC. The decision to investigate commercial uses of SHAC was made because the economics of commercial solar applications are different from those of residential applications. For example, commercial buildings usually have more lights, appliances, and occupants than residential buildings, and they are occupied at different hours.

ADL is monitoring active SHAC installations at five commercial buildings: a Connecticut delicatessen, an Indiana

Passive SHAC systems use building design to trap the sun's energy. South-facing windows, double-glazed windows, skylights, movable insulation, and thermal mass are the basic components.

credit union office, an Alabama office building, a Michigan pipefitters' training center, and a Florida utility's service center. Data collection at the five commercial installations began in 1980 and will continue into 1982; EPRI anticipates published results in mid-1982. Early results from these projects are showing the importance of proper control strategies in load leveling. Appropriate strategies can change the electric load shape presented by a commercial building with SHAC from a detrimental utility impact to a shape that actually improves a utility's load factor.

Passive potential

While active SHAC was being investigated, a different type of SHAC—passive—was also getting increased attention. Passive solar heating and cooling is in large part just sound energy-conserving building design. South-facing windows, double-glazed windows, skylights, movable insulation, and thermal mass (a slab floor or special internal concrete or water walls, for example) are incorporated into passive solar buildings to collect, transfer, store, and distribute solar energy for heating. The building can be similarly designed to keep the house cool—for example, by using night air to cool a thermal mass or water tank and recirculating the coolness during daytime.

Passive SHAC has several potential economic advantages that active SHAC lacks. Windows and walls will be required anyway, and careful design may be able to arrange them so that passive SHAC's first cost may not be much more than that of the basic construction. Passive solar uses common building materials and construction techniques, and as there are no complex mechanisms to break down, reliability is enhanced.

Passive solar systems are by no means ideal. For example, passive SHAC is most likely to be used on new housing, and new housing starts have been depressed for some time. Many passive systems have limited potential in the retrofit market. Passive systems are also more difficult to control than active systems: when a massive wall is inadvertently allowed to heat up, for example, it may not cool down for hours. Controls at this time are relatively primitive: the occupant of a passive house must actively adjust blinds, louvers, or shades to control heat transfer. Designers are now developing systems that can control temperatures automatically rather than manually.

Passive SHAC's future technology, economics, and impact are still unclear at this point. As with active solar, passive solar demonstrations and studies are now being conducted by a number of private individuals, utilities, DOE, and other agencies. To complement these activities, EPRI has chosen a research approach of data collection and analysis similar to the one it used to investigate active solar systems. EPRI's major project in this area is an assessment of passive solar's impact.

In the project's first phase, begun one year ago, JBF Scientific Corp. developed a methodology to help utilities identify the preferred passive solar designs for their particular areas and evaluate the impact of those designs on the buildings' electric loads and thus on utilities. As with EPRI's analysis of active solar, these evaluations take into account both the cost of the installed passive SHAC system and the cost of the backup energy the utility must provide. In the second phase this modified EMPSS methodology is being used to analyze the performance of passive solar home designs at seven utilities across the country. The modified program will be available early next year to assist utilities in predicting the effects of passive solar in their service areas.

Solar in perspective

The bustle of SHAC activity over the past decade marks a new era. It signifies a nation willing to save energy, a nation willing to try new engineering approaches. Some approaches are more promising than others, such as the increased use of insulation and the solar swimming pool heaters that replaced costly natural gas heaters in California. Other approaches, such as solar domestic hot water heating and space heating, are viable options in certain areas under specific economic conditions. And some approaches, such as solar cooling, remain beyond commercial application for thermodynamic reasons. The nation uses about 25% of its energy for comfort conditioning. Implementation of SHAC and conservation practices could decrease this by as much as 10%. This reduction is the grass-roots beginning of a national movement toward conservation and the beginning of a renewables era. ■

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This article was written by Nadine Lihach, feature writer. Technical information was provided by Gary Purcell, Energy Management and Utilization Division.

Geothermal: New Potential Underground

The Geysers, 910 MW of natural steam power in northern California, is the culmination of geothermal development in this country over the past 20 years. But that image is changing as the scarcity of steam resources is leading researchers to investigate the much more widely dispersed hot water resources that lie beneath the earth's crust. Geothermal energy is now on the threshold of rapid expansion and several technologies for using hot water resources are to be demonstrated over the next five years. Successful testing could lead to more than 16 GW of installed geothermal capacity by the year 2000.

Over thousands of years, volcanos, lava flows, hot springs, and geysers have been seen as picturesque and awe-inspiring manifestations of the vast heat store that lies beneath the earth's crust. Therapeutic uses of this naturally occurring heat can be traced to pre-Roman times, and limited electricity generation using natural steam was first successfully demonstrated at Lardarello, Italy, in 1904. It was not until fairly recently, however, that people considered capturing this natural heat from the earth—this geothermal energy—for use in space and process heating and in electricity generation on a large scale. Serious consideration of geothermal energy as an important renewable resource started in the 1950s and accelerated in the 1960s with the development of new theories about the nature of the earth's crust and the causes of such phenomena as faulting and volcanic activity.

As with many other renewable energy sources, much of the recent attention given geothermal is a result of the rise in fossil fuel prices over the past 10 years. Today, however, rapid advances in technology and new evidence pointing to substantial new geothermal resources—far more widespread than was once thought—have added impetus to geothermal energy development, both in the United States and abroad. During the past year total world geothermal generating capacity increased from 2.1 GW to 2.5 GW, continuing an established growth rate of about 18% a year. In the United States work by the U.S. Geological Survey indicates that recoverable geothermal resources may underlie most states.

There are three basic types of geothermal energy: hydrothermal, geopressured, and petrothermal. In a hydrothermal system, water becomes heated or is vaporized into steam by contact with hot rock. In geopressured systems, water heated in a similar way occupies an underground reservoir deep within deposits of sand and shale. This hot water is sealed off from the surface by impermeable shale layers, and is subjected to pressure from the overlying rock formations. In addition, the pressurized water is saturated with natural gas thought to have been produced by the decomposition of organic matter. In petrothermal systems, magma lying relatively close to the earth's surface heats overlying rocks to a high temperature. Water or some other fluid could someday be injected into such geologic formations and pumped out again, extracting the thermal energy.

Some 2400 quadrillion (2.4×10^{18}) Btu of geothermal resources have been identified in this country. In comparison, U.S. energy consumption last year totaled less than 80 quadrillion Btu. Though only part of this energy store is usable for electricity generation, recent work indicates that more than 220 quadrillion Btu of known resources could be used for that purpose. That translates into a generating capacity of about 24 GW over 30 years in the United States alone. This is equivalent to 14 billion barrels of oil.

Recognizing the potential in geothermal resources, electric utilities, resource companies, DOE, and organizations like EPRI are pushing for a rapid expansion of geothermal energy as an electricity source. U.S. geothermal generating capacity is expected to double from its current level of about 930 MW over the next 5–10 years. If current growth rates continue, as much as 16 GW of electric generating capacity could be operating by the year 2000, mostly in the western states.

Most of the current U.S. capacity, some 910 MW, is in a sprawling power plant in northern California, The Geysers. Operated by Pacific Gas and Electric Co., the plant first began producing electricity in 1960 from an 11-MW unit. Since then, 14 units have been added, raising the plant's capacity to 910 MW. By the year 1990 PG&E plans to have 2000 MW of capacity installed.

The Geysers plant produces electricity by channeling naturally occurring dry steam through turbine generators. The steam forms when rainwater seeps down into rock that has been heated by geologic activity, such as volcanism. Wells tap the steam and send it directly into the turbine, making these systems the easiest and most economical to operate.

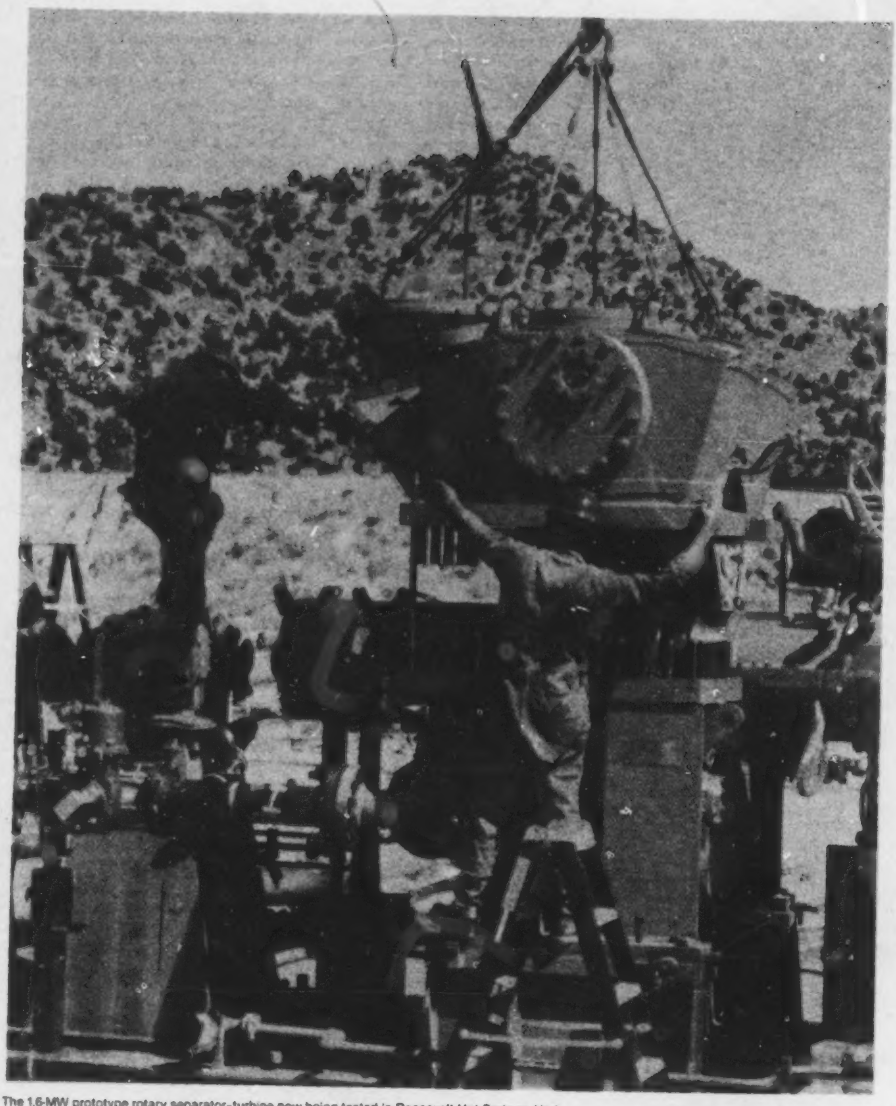
"The Geysers is an amazing resource," says Vasel Roberts, manager of the Geothermal Power Systems Program at EPRI. "Our figures show that there is at least enough steam to produce 2000 MW there for 30 years and perhaps longer. In addition, since most of the heat is in the rock formation, not in the steam, it may be possible to prolong reservoir life and expand capacity by water injection."

A new focus

Unfortunately, dry steam is a rare commodity, accounting for only 0.5% of the U.S. geothermal resource base. Far more common is another hydrothermal resource—hot water. Until recently, hot water received relatively little attention as a potential electricity source, but this form of geothermal energy has now become the focus of geothermal development and much of the geothermal research in the United States. In the past year the first two U.S. facilities to generate electricity with hot water came online. Their combined capacity is only 20 MW, but it has been estimated that by the year 2000, more than 85% of geothermal-derived electricity will come from hot water resources.

The reason is simple, as Roberts explains. "Our present knowledge suggests that if geothermal is going to grow beyond The Geysers in the near term, it must be done with hydrothermal resources. These offer the best potential because we know more about how to recover the energy and use it than about geopressured or petrothermal systems."

For high-temperature (above 210°C) water, direct-flash technology has been employed widely in Japan, New Zealand, Italy, Mexico, and elsewhere. Basically, hot water is drawn from the reservoir and its pressure is dropped, causing some of the water to vaporize (flash boil) to steam. This steam is then run through a turbine the same way natural steam is used at The Geysers.



The 1.6-MW prototype rotary separator-turbine now being tested in Roosevelt Hot Springs, Utah, is expected to increase resource utilization efficiency 15–20% by capturing energy at the wellhead from both the hot water and the steam found in geothermal fluid.

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In this country the first pilot plant using a direct-flash steam cycle recently began operation at Brawley, California. The 10-MW unit is operated by Southern California Edison Co. and Union Oil Co. of California. Successful testing at Brawley, plus positive data from other nations, is expected to lead to a rapid growth in direct-flash steam-cycle plants. Several plants, each with a capacity of 20–50 MW, are currently planned, including units in California, Nevada, New Mexico, and Utah.

An improvement in direct-flash technology is being developed to reduce the cost of power from high-temperature hot water resources. The idea is to use energy that would otherwise be lost when flashing the hydrothermal fluid, thereby increasing resource utilization. To accomplish this, a device known as a rotary separator–turbine (RST) has been designed and tested under an EPRI contract.

With an RST coupled to a steam turbine, the system works in this manner. Some flashing occurs in the geothermal well, so the fluid arrives at the wellhead as a two-phase mixture of steam and water. The mixture is then expanded through a nozzle to produce more steam and impart kinetic energy to the water. At this point, the water is captured in a rotating drum where it is separated from the steam by centrifugal acceleration. The steam is drawn off and sent through a normal steam turbine, while the water is sent through a special liquid turbine, which converts its kinetic energy to electricity. The water is then reinjected into the formation. In tests at Roosevelt Hot Springs, Utah, an experimental 20-kW RST unit achieved resource-utilization efficiency that was 15–20% higher than that of single-stage, direct-flash systems, according to Roberts. Testing of a larger prototype is under way, and if the results are favorable, RST units could be commercially available in 1986.

A high priority at EPRI and elsewhere is development of moderate-temperature (150–210°C) hydrothermal resources. "We looked at the thermal quality of our hydrothermal resource base and found that about 50% of the energy is in moderate-temperature resources," Roberts explains. "We felt that the direct-flash technology, which has been used extensively around the world, would be adequate to develop high-temperature, low-salinity resources at competitive prices. So our objective now is to accelerate the development of the moderate-temperature resources."

This effort has concentrated on the binary cycle, a process in which hot geothermal fluid is used to vaporize a secondary fluid that boils at a lower temperature. The process is now being tested on small-scale plants at East Mesa, California, and Raft River, Idaho. The first full-scale demonstration of the binary-cycle concept will be a 45-MW plant at Heber, California, in the Imperial Valley just south of El Centro. That facility, currently being designed, should begin operation in late 1984.

In the binary-cycle system, hot geothermal fluid in a closed loop is brought into close proximity to a second loop carrying the working fluid, likely to be a hydrocarbon with a low boiling point, such as isobutane or isopentane. The heat from the water is transferred to the working fluid through a heat exchanger, and the hydrocarbon boils as a result. That vapor is then sent through a turbine to generate electricity.

For several reasons, EPRI's staff believes this system will be the most efficient, most reliable way to generate power from moderate-temperature resources. First, for a typical resource in this category, a binary system would require only two-thirds the geothermal fluid a direct-flash system needs to generate the same amount of electricity. Although this advantage varies with resource temperature, it is substantial, translating into lower power cost and helping to conserve the resource. Second, the binary cycle can be operated as a closed system, unlike the direct-flash and natural steam systems. This way, after use, all the geothermal fluid can be redeposited into the formation, where it can again come in contact with hot rock and be reheated and reused. This operating mode can be environmentally advantageous in many cases.

The Heber plant, which will cost an estimated $122 million to build and operate through the demonstration period, will give utilities vital information about the design, performance, operation, reliability, and economics of a commercial-size binary-cycle system. The project is being cosponsored by EPRI, DOE, San Diego Gas & Electric Co., the Imperial Irrigation District, the California Department of Water Resources, Southern California Edison Co., and the state of California.

According to Roberts, hydrothermal demonstrations are the most crucial programs to the geothermal industry. For example, at Heber, the results of the demonstration are expected to further future commercial development of binary-cycle systems by removing cost and performance uncertainties that could not be resolved through research at small experimental facilities. In fact, a successful demonstration at Heber could make the binary cycle a commercially available technology by the end of 1986.

Recent developments at the national level, however, could have an impact on future work. The new national energy policy includes a deemphasis on near-term R&D, and this, coupled with the massive cuts in the federal geothermal program budget, could have long-term effects on geothermal development. Although it appears that federal funding for the Heber project will continue, should federal support be withdrawn, development of binary-cycle system technology is likely to become a very protracted process. According to Roberts, "An absence of federal support could mean that development of half of the known geothermal resources could be delayed indefinitely."

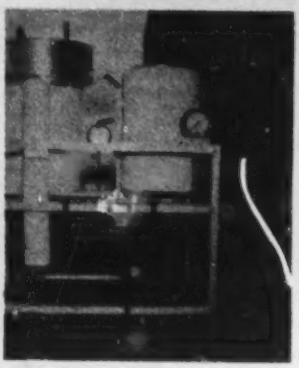
Common problems

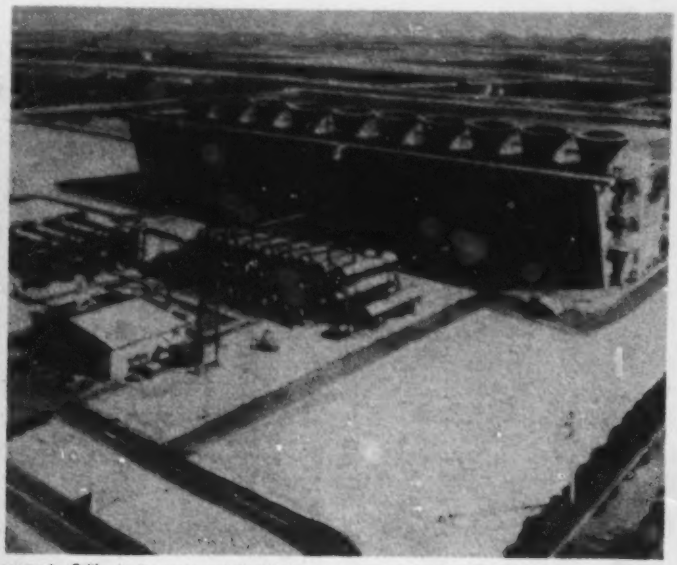
Though plant designs for natural steam, direct-flash, and binary-cycle systems are

quite different, the plants share certain problems. One of these is scaling. Most hydrothermal fluids contain some quantities of dissolved minerals, and some contain very high concentrations. As the temperature of the brine drops during well flow, flashing, or heat exchange, the minerals can precipitate out and reduce fluid flow and heat exchange.

In response to this problem, EPRI has developed a series of computer programs that will enable engineers to understand more fully the scale problems they are likely to encounter at a given geothermal site. The computer codes simulate scale formation at different points within a geothermal system by using input data on brine chemistry and operating parameters such as temperature, pressure, and fluid flow. The codes allow engineers to analyze the effects of changing certain operating characteristics of a plant, thereby allowing formulation of an optimal design.

To complement the computer codes, EPRI has sponsored a field test program that employs a mobile geothermal fluid chemistry laboratory to help upgrade the data base on the scale-forming components of different geothermal brines and on scale formation rate. In addition, a recent 30-day test by Sierra Pacific Power Co. in Nevada examined the effect of introducing a scale-inhibiting substance into the geothermal fluid to control scaling. Other utilities participating with Sierra Pacific include Portland (Oregon) General Electric Co., the Sacramento Municipal Utilities District, and the Eu-





At Brawley, California, the nation's first direct-flash pilot plant began operation last year (above left). Meanwhile, a key demonstration project that could lead to development of many moderate-temperature resources is being planned for 1984 at Heber, California. Tests at the 45-MW Heber plant are part of a project to examine the feasibility of a binary system at commercial scale.

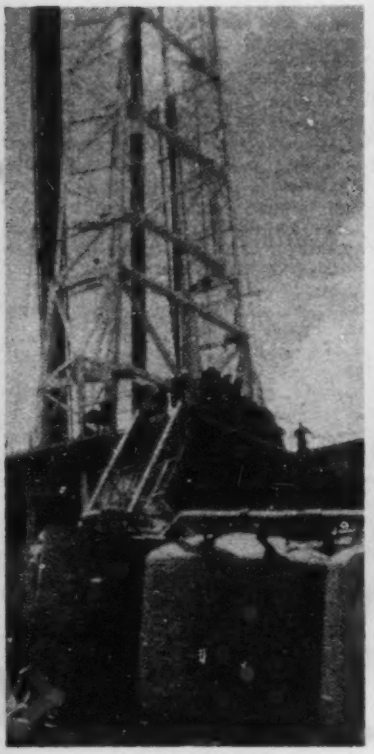
Once a major impediment to geothermal development, scale formation can now be controlled with the help of an advanced fluid sampling system developed under EPRI contract. Housed in a mobile test van, the sampling system can be easily transported to a geothermal well site to analyze the geothermal fluid there. These data, used in conjunction with EPRI-developed computer codes, can help engineers optimize the geothermal system design for the fluid chemistry in their area.

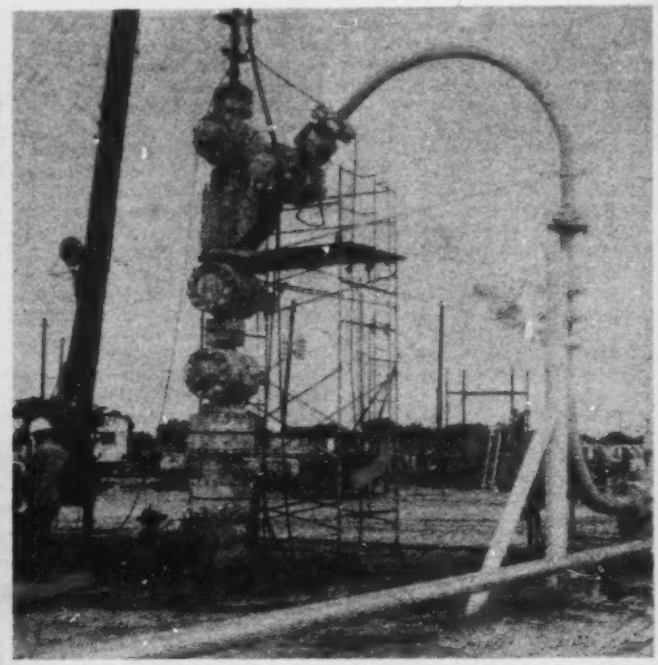
gene (Oregon) Water & Electric Board.

These developments show that the problem of scale formation is yielding to research efforts. "Scale is still a difficult problem, and we have a lot of work to do before we can control it," comments Roberts, "but significant progress has been made. Not long ago, some of the high-salinity brines were written off as unmanageable, even though some were high-temperature fluids. Now these fields are being seriously considered for electricity generation."

Another problem that research is solving involves noncondensable gases found dissolved in many hydrothermal fluids. Because these gases can reduce thermal efficiency, accelerate equipment wear, and cause environmental concerns, removing them has been an EPRI research objective for the past several years. Hydrogen sulfide (H_2S), a noncondensable toxic, noxious gas, is a particular problem at The Geysers, where it is found in the primary steam at concentrations of around 200 ppm. At one time H_2S was a serious impediment to resource development at The Geysers; and even now, although the gas can be controlled to meet environmental standards, the process is not without some negative operational side effects. So it is there that EPRI teamed up with PG&E to test an advanced H_2S abatement system to remove the gas without seriously impairing plant efficiency.

The approach, tested by EPRI contractors on a small scale, has proved technically feasible. In this system, steam from the reservoir is condensed in a vessel, while the H_2S and other undesired gases (which do not condense at the operating





At Pleasant Bayou, Texas, scientists are using this test well (above) to ascertain if the hot water and dissolved methane found in geopressured systems can be used in combination to generate electricity economically. Use of petrothermal resources is a longer-term issue, but an important one, as dry hot rock represents some 85% of the nation's geothermal resource base. Drill rigs like this are being used to create test wells that will provide information on the mechanics and thermodynamics of petrothermal systems.

temperatures used) are removed. The water is then revaporized by heat from incoming steam and sent into the turbine. The unique advantages of this concept are that it is simple and economical to operate, and it removes the noncondensables before the fluid reaches the turbine. The system appears to be efficient, with a net power loss of only a few percent. It removed most of the noncondensable gases, including an average 94% of the H_2S during experiments run at a 1000-lb/h (12.6-kg/s) steam flow.

Plans now are to scale the system up to a 2.5-MW pilot unit that handles 40,000 lb/h (504 kg/s) of steam. The construction of that unit will be complete in 1983. If test results are successful, a further scale-up to commercial size will probably occur.

Energy in solution

In some cases, gases combined with geothermal brines could be sources of additional energy. Such is the case in geopressured systems where methane is found dissolved in the water. In most geopressured wells, the water is not hot enough to justify the cost of drilling a well for the thermal energy alone. Studies have been under way, however, to examine the economic feasibility of generating electricity by combining a combustion system that burns the methane with a binary-cycle system to capture the geothermal heat.

Work to determine the extent and quality of geopressured resources is still in the preliminary stages, involving both studies and the drilling of test wells. Although results of these tests were not as encouraging as had been hoped, a recent examination by Southwest Research Institute for EPRI indicates the energy potential from 20 prospective geopressured sites along the Texas and Louisiana Gulf Coast could total 5.3 GW over 30 years. The study estimates that 1.1 GW of capacity could be on-line within the next 20 years.

Currently, DOE is continuing to fund a program to more fully evaluate the resource potential from geopressured systems, and although no specific plans have yet been made, Roberts believes a pilot plant to test resource recovery will be built in this decade. The future development of geopressured systems is more a question of economic viability than of technologic capability. "Industry knows how to drill the wells; and hydrothermal technology can be adapted to generate electricity if the energy in geopressured resources is sufficiently concentrated," Roberts explains.

This cannot be said of the largely unexplored petrothermal resources, which account for some 85% of the geothermal resource base in the United States. But development of extraction technology is continuing with the support of about $14 million annually from DOE, Japan, and West Germany. At a site near Los Alamos, New Mexico, two sets of test wells have been drilled, and significant progress on the technical issues connected with petrothermal resources has been made. Current experiments involve drilling pairs of wells into beds of dry hot rock. Water injected into the wells causes the rock between them to fracture, creating an underground heat exchanger. The idea is to inject water into one well, let it flow through the hot rock bed, and then extract thermal energy in the form of heated water from the second well.

Even after the technical feasibility of the concept is established, however, significant economic obstacles could remain. These wells must be drilled in hard rock and may need to be deeper than conventional wells, making them considerably more expensive than the relatively shallow wells required to extract hydrothermal resources. In addition, two wells are required for the process, instead of the normal single hole. Because of these factors, petrothermal resource exploitation could be prohibitively expensive unless the rock underground is very hot; far more study of the mechanical and thermodynamic properties of these systems will be necessary before development of dry hot rock beds will be practical.

For now, most of the available R&D resources are being channeled into research on the better-understood geothermal systems. How much money will be available, of course, depends on the outcome of federal budget debates, but it is likely that all the federal energy R&D programs will be affected.

In the area of hydrothermal technology especially, federal cutbacks will have a long-term effect because developers will have to use the limited existing technology for a longer period of time. This could mean the industry will have to concentrate on the highest-quality geothermal resources, which represent only about 25% of the known hydrothermal resource base.

In the present business climate, industry is not expected to expand its R&D efforts to include those areas dropped by the federal government. But some work will continue along a mainstream path that leads directly to more electric power. The incentives to do so are strong, especially with the 24 GW of hydrothermal resources already identified in this country. Geothermal reservoirs are renewable, and the availability of the plants already on-line has exceeded 80% in most cases. These facts, coupled with the need for indigenous sources of energy, are making geothermally generated electricity a more attractive alternative every day.

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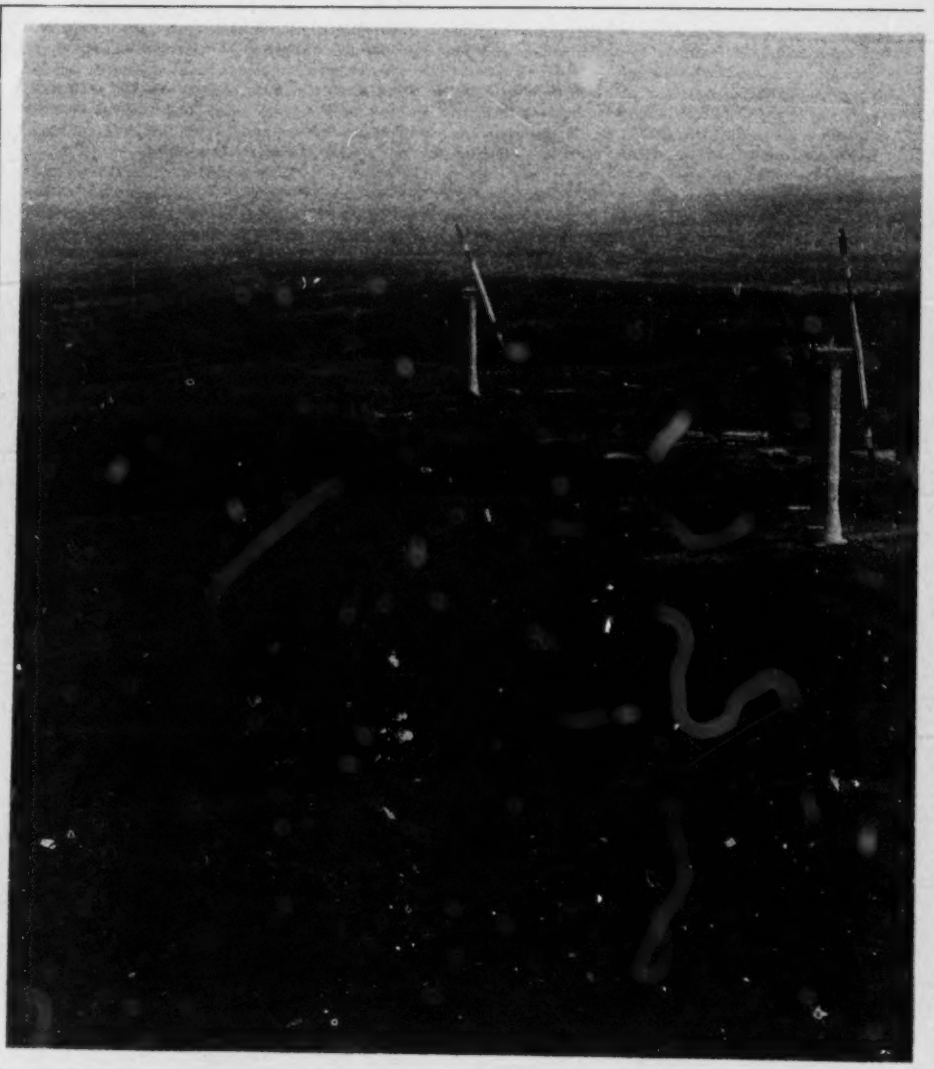
This article was written by Michael Charlson, communications specialist. Technical background information was provided by Vasel Roberts, Advanced Power Systems Division.



Wind:
Prototypes on the Landscape

Wind machines of the future are evolving through a carefully engineered program of wind turbine design. DOE–NASA's second-generation machines (MOD-2) are now up and gathering performance data on the grasslands of southcentral Washington, and third-generation designs—intended to lower costs and improve performance—are on the drawing boards. If research progress can be maintained at the current pace in spite of federal budget cuts, researchers should know in a few years how much of this vast but mercurial resource can be tapped for electricity generation. Clusters of mass-produced multimegawatt machines are the ultimate goal for utilities.

Large wind turbines for utility applications are rapidly emerging as one of the more promising renewable energy options. There are a number of sound reasons for the recent upsurge in wind power development activities. Wind turbine development programs are beginning to yield promising results. Wind machines may provide a way to reduce oil and gas consumption with a technology that has a relatively low cost of entry for utilities. Because wind power systems can be developed in small increments over a period of several years, the potential risk is relatively low. Moreover, wind energy is widely available throughout the world, although some regions have a much better wind resource than others, and the resource can vary within a small area.

DOE and other agencies of the federal government have been supporting a wide range of wind power R&D. The rapid advances in technology during the past few years are a triumph of the R&D process, but the job is not yet complete. Significant cost reductions and improvements in operating performance are still needed and are feasible, but the requisite advanced systems are still on the drawing boards. It is generally believed that these systems, incorporating additional advances in technology, must be designed, built, and tested to make wind power competitive in widespread applications. Because of anticipated budget cuts in the federal wind energy program, there is considerable uncertainty as to how and when needed cost and performance improvements will be demonstrated.

There is little doubt that utility participation is essential if wind is to make a significant contribution to the U.S. energy supply. Economies of scale, distances between good wind sites and population centers, space requirements, and maintenance demands make utilities the logical primary market, and probably the only significant market for large wind turbines.

Wind power's potential value is essentially in the displacement of fuel consumption rather than in the displacement of planned generating capacity. Fuel displacement means the saving of a specific type of fuel, such as oil, coal, or nuclear, by substitution of another energy source—in this case, wind. Under normal operating circumstances, a utility would preserve its most expensive fuels, typically oil or gas, during windy periods; practical limitations on generating unit cycling rates usually make it uneconomical to back off large baseload generating plants, such as coal and nuclear, for intermittent periods of wind availability. Thus, utilities that have a high dependence on oil and gas and are situated in or near windy areas appear to be promising markets for large wind turbines.

As wind is intermittent, few or no credits for capacity displacement are likely to be realized from wind power in most applications. However, if wind turbines become inexpensive enough, they may be economically attractive for their fuel displacement value alone.

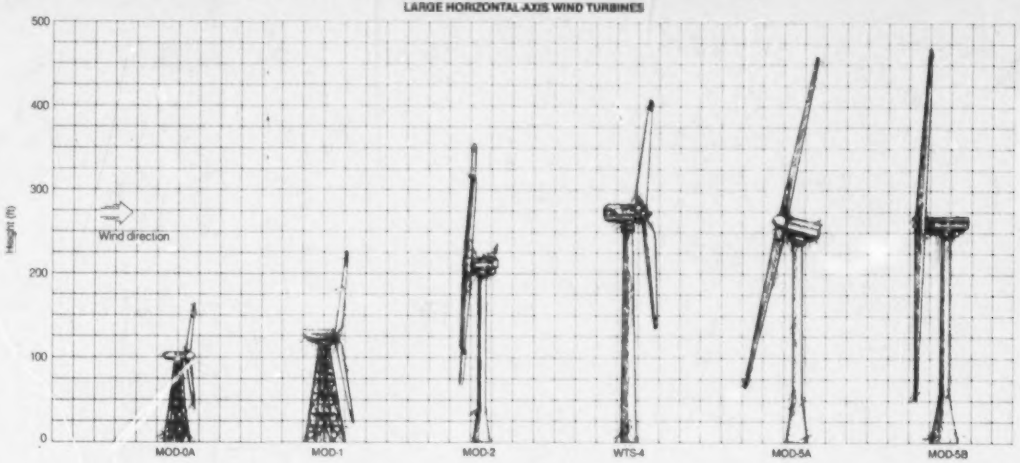
Technology development

Currently, the most advanced technology being developed by major industrial sources for harnessing wind power is the large, horizontal-axis wind turbine with propeller-type rotor blades. With horizontal machines, the axis of rotation is parallel to the ground; large machines are nominally considered to be those with rated power outputs over 100 kW. The National Aeronautics and Space Administration (NASA) is the manager of horizontal-axis system development and field test programs for DOE and the U.S. Bureau of Reclamation.

The first generation of these machines included the 100-kW MOD-0 machine that was first tested in September 1975 at NASA's Plumbrook station near Sandusky, Ohio; four 200-kW MOD-0A machines (Clayton, New Mexico; Culebra Island, Puerto Rico; Block Island, Rhode Island; and Oahu, Hawaii); and one 2-MW MOD-1 machine in Boone, North Carolina.

The MOD-0A sited in Hawaii incor-

LARGE HORIZONTAL-AXIS WIND TURBINES



	First Generation		*Second Generation*		*Third Generation*	
Height of blade axis (ft)	100	140	200	262	250	262
Rotor diameter (ft)	125	200	300	256	400	420
Rated power (kW)	200	2000	2500	4000	6200	7200
Rated wind speed at 30 ft (mph)	18.3	25.5	20.0	26.4	20.4	20.5
Cut-in/Cut out speed at 30 ft (mph)	6.9/34.2	11.0/35.0	9.0/36.0	9.7/49.7	7.0/49.3	4.3/46.3
Weight on foundation (tons)	45	325	310	389	600	630
Weight/Rated power (lb/kW)	447	325	247	194	193	175
Annual electric output at 12 mph (GWh)*	0.64	2.4	7.0	7.0	16.7	18.9
Annual electric output at 16 mph (GWh)*	0.98	5.1	11.3	13.0	27.1	29.9
Prime contractor	Westinghouse Electric Corp.	General Electric Co.	Boeing Engineering & Construction	Hamilton Standard Div., United Technologies Corp.	General Electric Co.	Boeing Engineering & Construction
Location (year of first rotation)	Clayton, New Mexico (1977); Culebra Island, Puerto Rico (1978); Block Island, Rhode Island (1979); Oahu, Hawaii (1980)	Boone, North Carolina (1979)	Goldendale, Washington (3 units: 1980, 1981, 1981); Medicine Bow, Wyoming (1981); Solano County, California (1982)	Medicine Bow, Wyoming (1982)	To be determined	To be determined

*Assumptions: 90% machine availability, wind speed averaged at 30 ft above flat level terrain, Rayleigh wind speed distribution. The relative performance of specific designs is dependent on site wind characteristics.

1173

porated improvements over the three earlier MOD-0As in its drive train, yaw-drive system (which keeps the turbine aligned with wind direction), and rotor construction. These improvements, together with the excellent wind resource in Hawaii, resulted in a very high rate of energy production. Between the start of operation in July 1980 and mid-November 1981, the machine has produced over 1.14 GWh of energy, and its capacity factor has been approximately 0.45. (Capacity factor is the ratio of actual energy produced over a given time period to energy that would have been produced if the unit operated at full rating over the same time period.)

These early machines were intended to be research prototypes for field experiments to verify and assess structural and aerodynamic performance and to obtain operating experience. Data gathered from these prototypes have resulted in considerable improvements in second-generation designs. Additional useful operating experience is being obtained from the early machines in ongoing test programs.

The most advanced design developed by NASA to date is the MOD-2, and it represents the second generation of large wind turbines. This machine has a two-bladed rotor situated upwind on a cylindrical tower that is 200 ft (61 m) in height. The rotor span is 300 ft (91 m), the length of a football field, and it is configured as a continuous structure with no hub. The tips of the rotor can be pitched for speed control. The machine starts to generate power in a 14-mi/h (6.3 m/s) wind (measured at the top of the tower) and achieves its rated power of 2.5 MW when wind speed reaches 27.5 mi/h (12.3 m/s). It shuts down automatically in winds over 45 mi/h (20.1 m/s) to prevent structural damage. Last May three MOD-2 machines were dedicated at Goodnoe Hills, near Goldendale, Washington.

The third-generation large wind turbine, the MOD-5, is now on the drawing boards. The goal of the MOD-5 wind turbine project is to design and fabricate advanced multimegawatt wind turbines that will reduce the cost of energy to approximately 30% below design goals for the second generation. The two MOD-5 conceptual designs have rated power outputs of 6.2 and 7.2 MW. They would be larger than the MOD-2, with blade spans of 400 and 420 ft (122 and 128 m), respectively. In addition, the MOD-5 may employ such new features as two-speed or variable-speed operation, induction generators, and the use of laminated wood rotor blades.

Concurrently, DOE is supporting other turbine designs that may offer technical and economic advantages in the future. One type, the vertical-axis (Darrieus) rotor, may eventually be cost-competitive with the horizontal-axis systems in some applications. Invented by G. J. M. Darrieus of France in the 1920s, it has egg-beater-shaped blades. Sandia Laboratories in Albuquerque is managing the development of the Darrieus design for DOE. Other more innovative, but less developed, designs are also under study by DOE.

Aided by federal and industrial support, a number of large machine developers have evolved. Among these are Aluminum Co. of America; Bendix Wind Products Co.; Boeing Engineering & Construction; General Electric Co.; Hamilton Standard Division of United Technologies Corp.; Merkham Energy Development Co.; Westinghouse Electric Corp.; and WTG Energy Systems, Inc. The widespread activity by a variety of developers is the foundation from which a competitive large wind turbine could emerge in the next several years.

Experts in the field believe that it is desirable to develop the largest feasible multimegawatt machines for most utility applications (especially for sites with large open land areas and uniform wind flow). However, some specialized situations are also expected in which unusual site topography or some other siting constraint would make submegawatt large wind turbines best suited. For example, the terrain could be so rough that it is not possible to transport and construct a multimegawatt machine. Further, in the case of some small utilities, only a relatively small amount of wind power may be required. Thus, there is justification for developing large wind turbines in both multimegawatt and submegawatt sizes. At this time it is not clear which size range of turbines will be most economical in mass-produced quantities.

A larger wind turbine rotor collects more energy by virtue of its larger blade sweep area. Also, for most terrain, winds are generally stronger at higher altitudes, and the larger machines (such as the MOD-5) are taller and therefore able to make use of the stronger winds. The larger machines have a higher power rating for each individual unit, so when a group of machines is clustered on the same site, fewer units are required to achieve the same aggregate rating than if smaller units are used. Fewer units would also simplify the cluster layout and interconnection problems and potentially reduce operating and maintenance demands.

Collectively, these facts provide the rationale for the MOD-5 program thrust. As Ronald Thomas, manager of the Wind Energy Projects Office at NASA's Lewis Research Center, puts it, "I believe these technological improvements will be readily attainable if the MOD-5 program is carried to completion. The third-generation machines would enable us to make better use of the good wind turbine sites."

"Wind has been a surprise to many people," comments Daniel Ancona, chief of DOE's Large Wind Technology Branch. "I think many saw it as a whim back in the early 1970s. But today, people have discovered that the resource is better than they thought and the hardware to harvest it has come a long way." Frank Goodman, who is responsible for managing wind power activities at EPRI, adds, "Wind power is promising, and there are reasons to be enthusiastic about it. If current R&D programs are completed and their objectives are attained, wind

BRIEF

The Land Use Question

Requirements for land have often been cited as a major drawback to the development of renewable resource technologies for generating electricity. It is now becoming clear that this concern may not be as critical as was once thought. Although some renewables will require more land than conventional power technologies because of the diffuse nature of their resources (wind and sunlight, for example), it is not so much the amount of land itself or even the cost of the land that is the obstacle. A more important land concern, common to several of the renewable resource technologies, is the problem of siting.

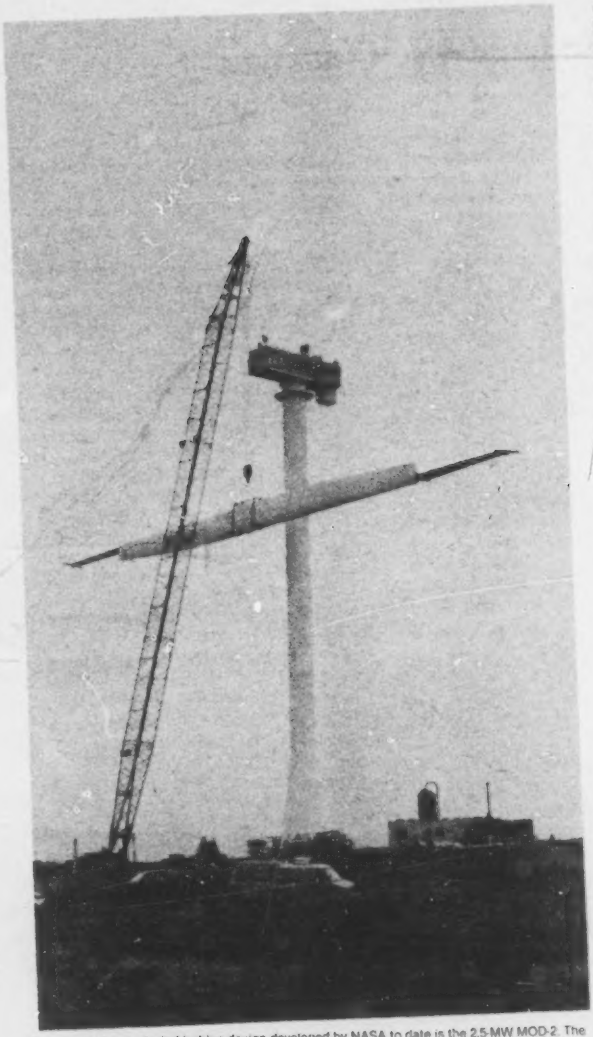
As has always been the case with hydro plants, the first consideration must be finding a location that offers an energy resource in sufficient quantity to allow its economic use. Geothermal power plants can only be built where a geothermal energy source can be tapped, as with The Geysers in California. The choice of sites for wind turbines is limited to areas with high, relatively steady winds. Direct solar conversion plants, such as solar-thermal central receiver and large-array photovoltaic power plants, will require areas with abundant sunshine, such as those found in the Southwest.

The cost of land for power plant sites is related to the land area needed, as well as to the type of terrain. Geothermal plants require roughly the same size site as a coal-fired plant of the same capacity, exclusive of the land associated with coal mining activities. A direct solar plant, on the other hand, will require about one square mile of land per 100 MW of capacity. This is comparable to the land needed for a coal plant fired with surface-mined coal, including the land from which the coal is mined. Although this represents a need for significantly more land for direct solar options than for geothermal, desirable sites are likely to be found in arid areas where the cost of land is low. (The land cost is expected to be on the order of 1% of total plant cost, which will not be an economic barrier.)

Wind turbine clusters may require four or five times as much land area as direct solar plants of similar capacity to avoid interference between adjacent wind turbines. However, because of this wide spacing between machines, only a small fraction of this land need be dedicated entirely to the wind turbines themselves; much will still be available for other purposes.

For biomass, the land use issue is of greater concern. Far more land is necessary with this technology because almost all the energy conversion is performed by vegetation through the photosynthetic process, which has a low conversion efficiency. At best, 1% of the incident solar energy eventually appears as electricity, which is about one-tenth the conversion rate for most other solar options. In addition, unlike the deserts suitable for the direct solar options, land for biomass must be of good quality to ensure productive growth of the plants and trees to be used for combustion or conversion. Such high-quality land is relatively expensive and sought after for other uses, such as for food or feed crops.

So the land question is not simply How much? Except for biomass, this is a secondary consideration. More to the point is whether sites can be identified that are optimally suited to the application of new technologies for the development of renewable resources. □



The most advanced wind turbine design developed by NASA to date is the 2.5-MW MOD-2. The rotor is 300 ft (91 m) long and is mounted on a 200-ft (61-m) cylindrical tower. The boxcar-shaped nacelle on the tower houses the generator and drive train. The rotor weighs approximately 90 t.

could begin making a significant contribution to our overall energy needs before the end of the century."

Utility involvement

The foundation for that significant contribution is already taking shape on several utility systems around the country. In addition to hosting the improved DOE–NASA MOD-0A turbine mentioned earlier, Hawaiian Electric Co., Inc., has plans to purchase energy from a private developer who hopes to install an 80-MW cluster of wind turbines on Oahu by 1985.

Southern California Edison Co. is testing several wind turbine designs at its San Gorgonio Pass site near Palm Springs, California. By the turn of the century, SCE hopes to have wind contributing up to 3% of its energy requirements.

Pacific Gas and Electric Co. has contracted to purchase a 2.5-MW MOD-2 wind turbine, modified to operate in winds up to 60 mi/h (26.8 m/s). This unit is scheduled for operation in the spring of 1982. PG&E also has entered into an agreement in principle to buy energy from a 350-MW cluster proposed for installation by a private developer. It is hoped that this cluster will be fully operational by 1989. A contract has been signed to purchase energy from another cluster development, which may have a rating as high as 30 MW. Both SCE and PG&E are negotiating with several cluster developers at this time.

The U.S. Bureau of Reclamation has purchased two second-generation machines to be evaluated at its site near Medicine Bow, Wyoming. One is a 2.5-MW MOD-2 and the other is a 4-MW WTS-4. Ultimately, the bureau hopes to install approximately 150 MW of wind machines in the Medicine Bow region.

Several other utilities are involved in large wind turbine field experiments, negotiation of energy purchase agreements with independent developers of wind turbine clusters, and in some cases, both. Additionally, many utilities have begun siting work and long-range plan-

ning studies for use of wind power. This high level of activity in the utility industry has been motivated by the recognition that large wind turbines would provide an energy source with a relatively low capital risk, if the technology development is carried to maturity.

The primary objectives of EPRI's wind power activities are the transfer of technical information and the development of planning tools to help the utility industry prepare for using wind power. EPRI's efforts complement federal and private wind power research.

EPRI gathers, evaluates, and transfers data from wind turbine field tests to the utility industry on a regular basis. Three reports (AP-1317, AP-1641, and AP-1959) are available that document significant results of large wind turbine development and field tests. New reports in this series are expected semiannually.

Other EPRI projects in the wind area are directed toward developing methodology for wind turbine siting; evaluating utility experiences with wind power, including planning, siting, hardware procurement, project costs, and operation; developing market penetration estimates for wind power systems; and assessing wind turbine dynamic impacts on utility system operation. Initial results from these projects are expected to become available during 1982.

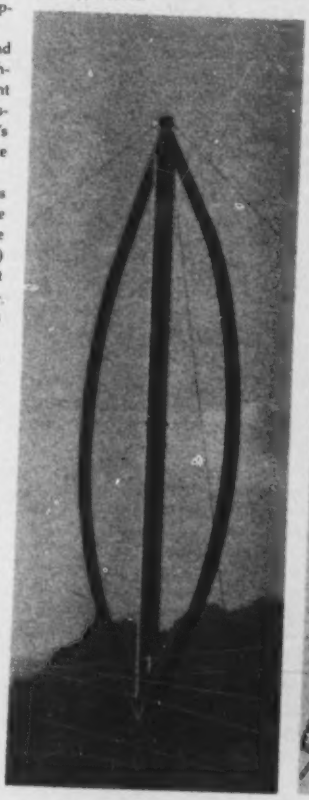
Wind resources and turbine siting

Two important, related areas of study are wind resource assessment and wind turbine siting. Complementary DOE and EPRI programs have evolved in these areas. DOE's role in wind resource assessment is being managed by Battelle, Pacific Northwest Laboratories (PNL) in Richland, Washington. The research goals are to begin detailed documentation of wind resources and to develop techniques to predict wind speed, direction, and profile that can be used to select the best areas for siting wind turbines.

Researchers gather information from weather station reports, analyses of relief maps and surface pressure maps, observation of wind-deformed vegetation and landforms, and direct measurement. In this manner, average wind power density at various locations has been charted on a seasonal and annual basis, and graphs have been prepared showing annual, monthly, and daily variations of wind speed and power, as well as curves of frequency and duration. Under DOE sponsorship, PNL has published a 12-volume atlas giving preliminary estimates of national wind resources.

To complement the DOE-sponsored resource studies, EPRI has initiated work to develop siting methods through a contract with PNL. A systematic procedure

Sandia Laboratories and the Aluminum Co. of America are sponsoring development of the vertical-axis Darrieus wind machine. Invented by G. J. M. Darrieus of France in the 1920s, this machine may eventually be directly cost-competitive with horizontal-axis systems in some applications.



A NASA MOD-0A machine at Kahuku Point on Oahu has been operating routinely for more than a year, and so far, the machine has produced over 1140 MWh of energy. Long-term operating experience such as is being acquired with this machine is essential for successful future technology development.

is being developed for selecting wind turbine sites by addressing relevant siting criteria, such as the amount of available wind energy, accessibility of roads, proximity of sites to existing transmission rights-of-way, influence of terrain features, environmental impact, meteorological hazards, compatibility with legal concerns, and land availability and alternative uses.

The availability and ownership of the land at and around a potential site are significant because a large cluster of machines must be spread over a considerable area. It is important to keep in mind, however, that the land supporting wind turbine clusters can be used simultaneously for other purposes, such as grazing, farming, and recreation, to the extent that such activities can be coordinated while maintaining adequate safety.

The future for wind

During the next few years, the results from wind turbine development and test programs should establish whether wind power will have a significant impact on the electric utility industry.

"In talking about wind's potential," EPRI's Goodman stresses, "it's critical to recognize that today's machines are experimental models; accumulated performance information on these machines is needed before they are committed to mass production. The R&D process cannot be short-circuited. To get from where we are now to the point where we have widespread use of wind power will require the continuation of a well-paced program with logical, achievable milestones. It's a matter of not promising too much too soon, of not rushing the technology so fast that a serious failure occurs that gives the program a black eye."

Earlier this year, two mishaps did occur. At SCE's San Gorgonio Pass site, a 500-kW vertical-axis machine experienced a braking malfunction caused by a programming error during a simultaneous wind gust and system voltage drop, and an overspeed resulted. Detection of the overspeed caused a second application of one braking system, which wore out its brake shoes. A rotor blade eventually pulled loose at the bottom, swung outward, and hit a guy wire. The guy wire failed and the machine collapsed.

Last summer one of the three MOD-2 wind turbines at Goodnoe Hills experienced a 60% overspeed because of a control system malfunction during a test of the emergency shutdown system. This resulted in damage to the generator and drive train. The unit is being repaired and should be back in operation in early 1982. All three of the Goodnoe Hills units have been modified to protect against recurrence of this problem. "All this is part of the R&D process," says Goodman. "It's to be expected, and the fact that specific mishaps have not recurred is a success in itself."

Despite the rapid momentum that wind power development has enjoyed in recent years, there is good reason for concern that this pace may not be sustained. The federal wind energy program is faced with substantial budget cuts. These cuts come at a time when the utility industry is on the threshold of obtaining performance information from several key wind turbine experiments, including data from the three MOD-2s at Goodnoe Hills. In addition, the MOD-5 wind turbine program has just reached the point of having two conceptual designs completed. It now appears that DOE may be forced to restructure its program, shifting away from new system development and performance testing.

In view of these changing circumstances, it appears the development process, at best, will be protracted unless increased support comes from other program sponsors to maintain the momentum that had been established in the past by the federal program. The utility industry will need performance information for several alternative wind turbine designs in order to fully understand the technology's prospects. Further, advanced wind turbines, such as the MOD-5, and a competitive wind turbine industry will be needed to enable the utility industry to derive maximum future benefit from wind power.

What will be the source of the support needed to keep wind power development on track? No one has a definite answer, but there are several options and possibilities, including restoration of DOE's wind power budget, continued and/or increased R&D by the fledgling wind turbine industry, greater utility-sponsored R&D, infusion of capital from interested private investors, and programs being carried out in other countries. The answer may emerge as a combination of some or all these sources, with the various sectors interested in wind energy working cooperatively to bring the technology to maturity.

EPRI's Goodman says, "I don't believe wind is going to be the singular answer to problems of future energy supply. But I do believe it's one of a blend of technologies that could help solve the energy problems the nation faces. Large wind turbine R&D in recent years has served as an excellent example of this country's vast technological capability. The challenge before us at this time is to make increased use of this capability in developing promising renewable energy options, such as wind power." ■

Further reading

Requirements Assessment of Wind Power Plants in Electric Utility Systems. Final report for RP740 prepared by General Electric Co. (3 vols.). January 1979. ER-978.

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Wind Power Generation Dynamic Impacts on Electric Utility Systems. Final report for TPS79-775 prepared by Zaininger Engineering Co., November 1980. AP-1614.

Large Wind Turbine Generator Performance Assessment: Technology Status Report No. 1. Technical report for RP1348-1 prepared by Arthur D. Little, Inc., January 1980. AP-1317.

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Large Wind Turbine Generator Performance Assessment: Technology Status Report No. 3. Interim report for RP1348-1 prepared by Arthur D. Little, Inc., July 1981. AP-1959.

This article was written by Marcie Lynn Smith, utility communications coordinator. Technical background information was provided by F. R. Goodman, Advanced Power Systems Division.

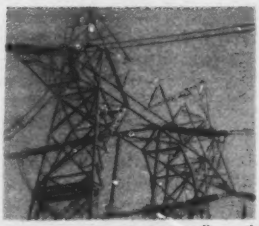
BRIEF

Integrating Renewables Into Utility Networks

Technologies for generating power from renewable energy sources offer a diversity of engineering challenges, but one particular challenge is common to all: how to integrate these new technologies into existing utility systems. The conventional modes of utility power generation—coal, oil, gas, and nuclear—fit conveniently into utility systems because they can be turned on as demand requires. Conventional modes of generation also deliver the smooth, 60-Hz ac power that the nation's electricity network was designed for.

But many of the renewables (solar and wind, for example) cannot be turned on at utility convenience. As utilities contemplate the construction of wind, solar-thermal, and photovoltaic power plants, they must also consider how these intermittent energy sources will fit into existing generation schemes to the greatest advantage. To integrate power from renewables in the most economic way, engineers must know not only how much fuel energy but also how much generation capacity the renewables can be counted on to displace.

Renewables do not always displace conventional fuel or generating capacity. For example, when extra power is required at periods of peak demand, solar or wind installations—by their intermittent nature—may not be producing energy, and utilities might still



require costly oil fuel (as well as oil fired capacity) to meet the peaks, despite renewables installations. Conversely, a solar or wind installatio may produce energy at times whe coal or nuclear baseload plants—a utility's most efficient power producers—are already delivering sufficient energy to meet demand. As a result, the fuel displacement value solar or wind might provide during these baseload periods might not justify the installation of solar or wind capacity.

As renewable technologies near the utility market, engineers are directing closer attention to the effect of these technologies on fuel and generation planning. For instance, EPRI's Advanced Power Systems Division has recently developed methods that utilities can use to determine the future value and role of wind, solar-thermal, and photovoltaics on their own systems. These methods use utility planning techniques currently available to the industry.

After a utility has decided that a renewable technology can be an advantageous addition to its total generation system, the new technology must be electrically integrated with the existing system. Renewables, such as solar and wind, may produce uneven bursts of dc or ac electricity rather than the 60-Hz ac power that conventional plants provide. Uncorrected surges of power from, say, a gust of strong wind might trip utility protection system components or instigate unstable network behavior. Inconstant power can cause efficiency losses and may damage utility and customer equipment. Power-conditioning systems that can tame variable electric output into regular ac form are essential to integrate new sources into utility systems. EPRI's Energy Management and Utilization Division has undertaken preliminary work in this area by developing a 10-MW power-conditioning system for batteries and fuel cells. Many of the technological approaches used for this system are also applicable to photovoltaics and wind.

Planning for the integration of emerging renewable energy technologies is just beginning. "But as use of these new technologies won't become widespread overnight, there's time to work out the interconnection problems," says APS Division's Edgar DeMeo confidently. "The industry can do a lot of engineering in 10 years." □

Solar-Thermal Electric:
Focal Point for the Desert Sun

Power towers are now being raised in several countries, but the Solar One project in the California desert is perhaps the most critical milestone on the path to commercialization. Information flowing from this 10-MW working laboratory will assist in modifying future designs and provide sound data for evaluating performance and cost. With the benefits of mass production, it now appears that these systems for converting concentrated sunlight to electricity could become competitive with oil- and gas-fired plants in the American Southwest. If research momentum can be sustained, demonstration plants could be on-line by the end of the decade.

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Bank upon bank of mirrors move slowly under the southern California sky, tracking the sun and concentrating its radiation on the receiver of a power tower nearby. Jutting 310 ft (94.5 m) above the desert floor, the tower looks a little like a rocket awaiting liftoff.

In a sense, the Solar One pilot plant, a joint DOE-utility project located in the Mojave Desert near Barstow, California, is a launchpad, but not for extraterrestrial travel. As the first U.S. 10-MW (e) solar-thermal pilot plant, it might well become the critical milestone for a joint industry-government commitment to the solar-thermal central receiver concept.

As Gerald Braun, director of DOE's Solar-Thermal Technology Division, has noted, the planned turbine roll at Solar One early in 1982, the first test of its electric output, represents a major event in efforts to advance this new technology to the point of commercial development.

Robert Hughey, director of DOE's Solar Energy Division office in San Francisco, adds that of all the solar-thermal conversion concepts, central receiver plants hold the greatest potential for electric utility applications. DOE and EPRI studies show that if carried through the test and demonstration cycles, solar-thermal central receiver power plants may be competitive in the Southwest with gas- and oil-fired plants.

"Of all the direct solar options under consideration by electric utilities today," says John Bigger, EPRI's solar-thermal project manager, "the prospects for solar-thermal conversion look the best." He adds that the most recent EPRI survey indicates that U.S. electric utility interest in solar-thermal energy is greater today than ever before, with utility support and participation in 68 solar-thermal projects this year.

What are the vital steps that remain to be taken for solar-thermal conversion to move from a promising prospect to an operating, commercial reality? Bigger sees two key steps: performance demonstrations and corporate commitments. "Pilot plants, like the Solar One project and five other central receiver tests starting up in Western Europe and Japan this year and next, are expected to contribute performance information and operating experience to encourage supply industries and electric utilities to make commitments to this emerging technology," says Bigger. This information and experience is needed to confirm the estimates of cost and performance made in earlier studies. Corporate commitments are needed to foster mass production, and hence economies of scale, in the construction of key components, such as heliostats (the mechanical tracking mirrors that reflect and concentrate solar energy).

A working laboratory

Deserts make ideal locations for solar-thermal conversion plants not only because the sunshine is abundant, which is critical, but also because land is relatively inexpensive and available. The Solar One site comprises 130 acres at Daggett, California, about 12 miles southeast of Barstow, California. It is owned by Southern California Edison Co., a sponsor of the project with DOE and the Los Angeles Department of Water & Power, the nation's largest municipal utility. The California Energy Commission is also a participant. In addition to providing the site, SCE joined LADWP in designing and building the steam turbine generator and other conventional components of the plant at a cost of about $21.5 million. McDonnell Douglas Corp. and Martin Marietta Corp. are the major contractors.

Solar One's start of operation is planned for mid-1982. The first two years of operation will include experimental testing of the major subsystems and evaluation of the operation and maintenance costs and requirements. This period will be followed by power production tests, which are designed to obtain longer-term operating, maintenance, and reliability data. The intent is to make more accurate estimates of commercial solar-thermal plant costs and performance.

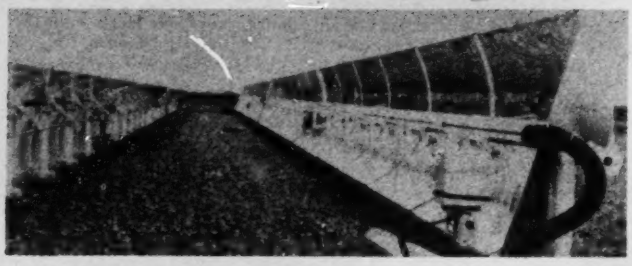
When operating, the plant will use 1818 heliostats, each containing 12 separate mirror facets. Preprogrammed coordinates will be used to allow the heliostats to automatically track the position of the sun across the sky. The concentrated beam of solar energy reflected from the heliostats will be aimed at the central receiver on top of the structural steel tower. The energy focused on the central receiver will convert water to steam to operate a conventional turbine generator, producing up to 10 MW of electricity, the amount of power needed to supply a community of 7000–10,000. At night or during periods of high winds, the heliostats will be moved to the stow position horizontal to the ground, with the reflecting surfaces facing downward.

Solar One will serve as a laboratory, providing information on which many future decisions will be based. Information on equipment reliability and failure, for example, will be coupled with system performance data. These data will be vital to the decision makers planning and designing the next solar central receiver installations, perhaps in the 30–100-MW (e) range. In addition, the Solar One test will provide electric utility personnel with first-hand experience, both in the operation and in the maintenance of the new technology. Utilities will monitor the information, experience, and performance data that develop from operation of the Solar One plant.

Next step: repowering

EPRI's Bigger believes information learned at Solar One, together with data from other ongoing experiments and central receiver pilot plants outside the United States, will pave the way for the next major step toward commercialization of solar-thermal conversion technology: implementation of a larger, precommercial project, probably a repowering plant. *Repowering* is a term applied to the concept of adding a solar-thermal conversion front end to an existing conventional fossil fuel power plant. Based on seven conceptual design studies recently completed (six were funded by DOE), the prospect exists that selected power plants

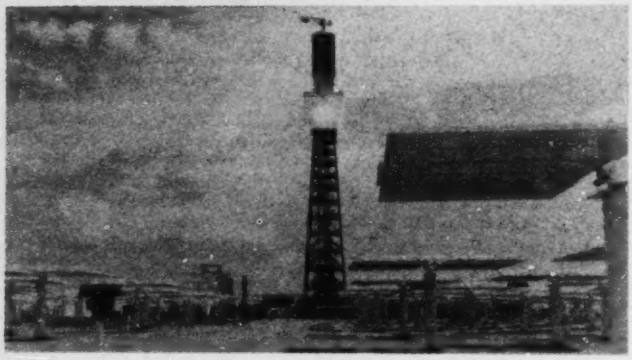
Flat plate collectors, like the rooftop unit providing energy for an air conditioning system at a Florida Power & Light Co. facility, are used to collect solar energy for water heating and the space heating and cooling of buildings.



Line focus troughs reflect solar energy onto heat transfer fluid moving through a focal line. Such systems are demonstrating their capabilities in providing thermal energy for a wide range of industrial and agricultural processes.

Line focus bowls being tested under DOE sponsorship use a large number of mirror segments attached to a spherical structure to concentrate solar energy on the fluid moving along a line. This concept differs from the others in that the heat receiver moves rather than the reflectors. Heat collected in a number of bowls may be used for heating or cooling buildings, steam production, or small-scale electricity generation. (left)

Point focus dishes, like these DOE-funded test units, achieve high temperatures by using a number of mirrored reflectors attached to a single parabolic structure to focus intense solar heat on a receiver located at the focal point. Heat collected in this manner may be used to generate electricity, to provide energy for heating and cooling buildings, or to provide energy for many industrial and chemical processes. (right)



Central receivers, like this one near Barstow, California, achieve the high temperatures required for large-scale electricity generation by reflecting the energy received by hundreds of mirrored surfaces onto a single point, or receiver. The high temperatures achieved by central receiver units may also prove economic for many fuel and chemical production processes.

could be repowered and energy from the sun might replace as much as 20% of the expensive oil and gas now being burned. Future projects would demonstrate the concept of solar-thermal conversion in a conventional operating environment, and if the 20% savings in fossil fuels could be achieved at acceptable cost, such plants might be attractive.

Still, the cost of such systems remains a critical question. While the rising cost of fossil fuels is an obvious economic plus in the solar-thermal equation, it is also clear the cost of building the solar power plants is a major stumbling block. Estimates of the cost to modify and build solar repowering plants runs from $1500 to $4000/kW (in 1980 dollars), assuming a heliostat cost of about $250/m^2. EPRI analyses indicate that heliostats must be available for about half that cost if commercial solar-thermal plants are to compete with those now burning gas and oil for electricity generation. Even greater cost reductions would be needed to compete with coal-fired generating plants. Much of the development work supported by DOE's Solar-Thermal Program and under way in private industry is aimed at reducing costs by designing more efficient components and systems. Results of DOE's Second-Generation Heliostat Program were announced recently. This work covered a two-year test and development program with four potential heliostat suppliers. The results indicate the price of these new heliostats, if ordered in sufficient quantities, could approach the $110/m^2–$150/m^2 range.

DOE has also examined a number of advanced central receiver concepts; the performance of each is considered to be better than the first-generation water-steam system now being installed at the Solar One pilot plant. These concepts include advanced water-steam systems, liquid-metal and molten-salt systems, and a combined-cycle concept. With DOE support, Martin Marietta has developed a 5-MW (th) molten-salt receiver, which was designed, built, and successfully tested at DOE's central receiver test facility (CRTF) at Sandia Laboratories in Albuquerque, New Mexico. A smaller-size liquid-metal (sodium) receiver panel was designed and built with private industry funds; it will undergo solar testing in the late-1981 through early-1982 time period.

Developing hybrid plants

The cost of developing solar-thermal energy is affected by an inherent handicap shared by all the emerging solar electric options: reliance on an intermittent source. How does a utility compensate for the lack of energy at night or on overcast days? To circumvent this problem, EPRI studies have concentrated on the Brayton-cycle gas-cooled solar-thermal system in a hybrid mode. Such hybrid power plants would use solar energy when the sun is shining, then burn oil or gas to generate electricity on cloudy days or at night. In contrast, the federal program is emphasizing thermal storage as part of the solar power plant. (The Solar One facility at Barstow was designed to have a thermal storage system capable of producing 7 MW (e) for four hours, using an oil and rock mixture inside a 60-ft-diameter tank storage vessel.)

Unlike the Rankine-cycle water-steam systems (such as is installed at Solar One), Brayton-cycle systems use air, helium, or other gas mixtures as the heat transfer fluid in the solar receiver (*EPRI Journal*, June 1979, pp. 18–21). Such systems, under development by EPRI and DOE, have been successfully tested at DOE's CRTF and at other solar-thermal test facilities at the Georgia Institute of Technology and the U.S. Army's White Sands Proving Ground.

Whereas Rankine-cycle systems operate in the temperature range of about 1000–1100°F (538–593°C), with pressures in the 1000–2000-psi (6.9–13.8-MPa) range, solar Brayton-cycle receivers have been successfully tested with air at temperatures in the 1500–2400°F (815–1315°C) range. These higher operating temperatures have the advantage of offering potentially higher efficiencies; they have the disadvantage of encountering material problems, usually at about 1500°F (816°C). To address these material problems, EPRI and DOE have sponsored studies aimed at developing and using high-temperature metallic alloy and ceramic components in Brayton-cycle receivers.

EPRI full-system experiment

The next step in the EPRI Solar Program is an experiment involving a complete Brayton-cycle solar-fossil hybrid system to generate electricity. Called the solar-fossil hybrid full-system experiment, the system is now being designed and will use the 1-MW (th) receiver previously tested at CRTF from October 1978 to March 1979, which was developed for EPRI by Boeing Engineering & Construction.

The commercial gas turbine to be used in the full-system experiment will be equipped with a parallel trim combustor, which allows fossil fuels to supplement the sun in a solar-fossil mode of operation and increases the system's operating flexibility and reliability. The parallel trim combustor concept was developed under a separate EPRI contract with Solar Turbines, Inc., which is bringing this experience to the full-system experiment as a subcontractor to Boeing.

In accordance with EPRI's goal of providing a link between research, development, and commercial implementation by the electric utilities, Public Service Co. of New Mexico is coordinating activities of the recently formed Utility Test and Operations Group, whose members represent about a dozen utilities, most of them located in the Southwest. This group will provide technical assistance to Boeing and will conduct the experiment during the solar operating phase. The experiment will give electric utility operating and engineering personnel firsthand exposure to a complete solar-fossil hybrid generating system.

Several of the southwestern utility companies participating in this experiment have also been taking part in DOE's repowering projects, and they can

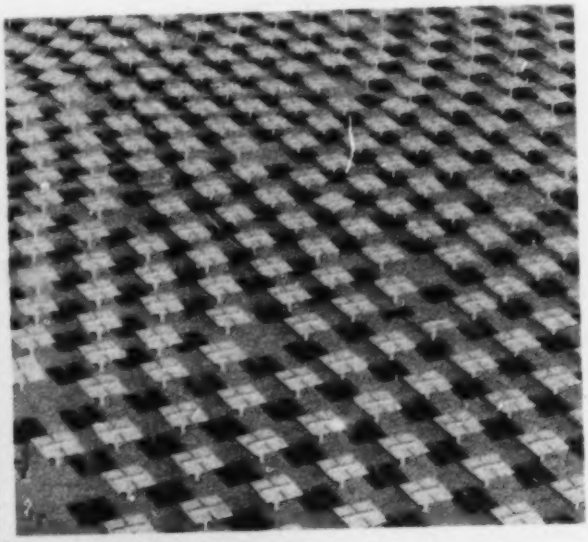
be expected to play a lead role in the development of solar-thermal conversion.

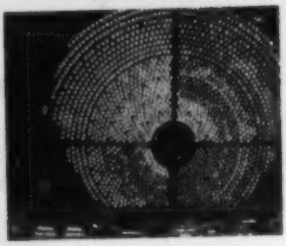
Information garnered from the full-system experiment and Solar One will be combined with data from other central receiver projects coming on-line throughout the world to advance solar-thermal central receiver technology and understanding.

Dishes, troughs, and bowls

In addition to the central receiver, or power tower, approach to solar-thermal energy conversion, considerable interest has also developed in various forms of dispersed, or distributed, solar-thermal systems. Such systems fall into two broad categories: point focus and line focus systems.

Point focus systems are similar to the power tower concept to the extent that the solar energy is focused on a central location. Rather than hundreds of heliostats focusing a solar beam at a distant receiver on top of a tower, however, a single mirrored tracking device in the shape of a parabolic dish captures the solar energy and focuses it on a receiver mounted a few feet above the dish. A special facility for testing dish systems and components is located at Edwards Air Force Base in California and is operated by Jet Propulsion Laboratory. Also, at Shenandoah, Georgia, DOE is currently building an array of parabolic dish concentrators to be used for electricity





Solar One, a 10-MW installation located near Barstow, California, is the nation's first solar-thermal central receiver electric generating station. A field of 1818 heliostats, controlled by computer, tracks the sun throughout the day and reflects its energy onto the receiver, where steam is produced. The steam is then sent either through heat exchangers for thermal storage and later use or to a conventional steam turbine that generates electricity. EPRI researchers believe information coming from the Solar One central receiver station will help advance this emerging technology and can lead to additional industry and utility commitments to continue its development.

SOLAR-THERMAL RESEARCH IN OTHER COUNTRIES

Interest in solar-thermal energy systems is not confined to the United States but is being actively pursued in a number of industrialized nations. Some of the major work currently under way includes the central receiver pilot projects described below.

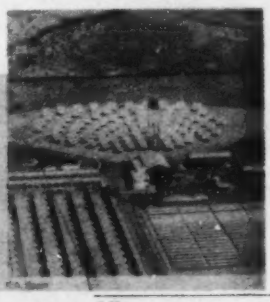
Almeria, Spain: The International Energy Agency has funded the construction of a 500-kW (e) small solar power system that uses liquid metal (sodium) as the heat transfer and thermal storage fluid. A cavity receiver located on top of a 140-ft (43-m) central receiver heats the sodium to 975°F (525°C). The 93 heliostats in the field provide 430 ft² (40 m²) of surface area and were supplied by the Martin Marietta Corp. The project is funded by several European countries and the United States; startup was in September 1981. This IEA installation also includes a (nominal) 500-kW (e) line focus system for a direct comparison of performance with the adjacent central receiver.

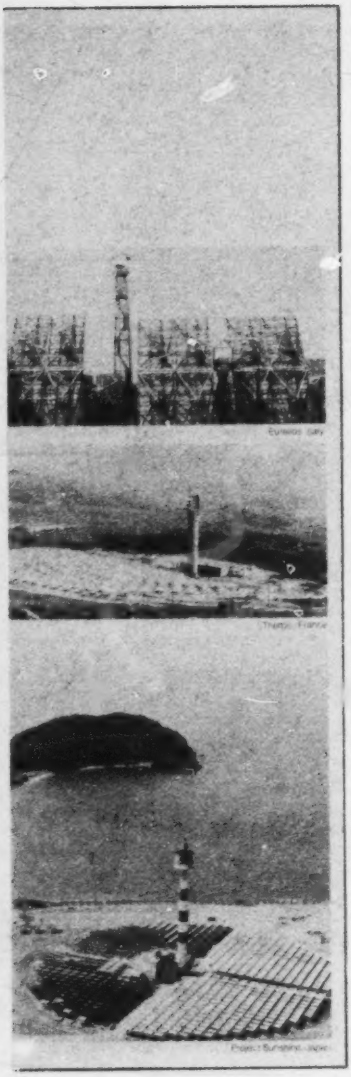
Almeria, Spain: A 1.2-MW (e) central receiver system is under construction and scheduled for completion in late 1982. Called CESA-1, the unit uses a cavity receiver to produce 975°F (525°C) steam. A German and a French firm each supplied 150 heliostats with 430 ft² (40 m²) of surface area. The unit has a thermal storage capacity of 3 MWh (th) and uses Hytec as the storage fluid. Funding is being provided by the Spanish Joint Committee for Scientific and Technological Cooperation and the United States.

Adrano (Sicily), Italy: Eurelios, a 1-MW (e) central receiver solar power plant, began operation in May 1981. The cavity receiver sits on top of a 180-ft (55-m) tower and produces steam at 950°F (510°C). A 30-minute thermal storage subsystem is used to even out cloud transients, and Hytec is the storage fluid. The project was developed by a consortium from Italy, Germany, and France.

France: In the Thémis project, a 2-MW (e) central receiver solar power plant will use molten salt as the transfer fluid, heated to 975°F (525°C) by solar energy reflected by 200 heliostats, each with a surface area of 560 ft² (52 m²) aimed at the cavity receiver. The storage system has 4 MWh (th) of capacity and uses Hytec as the storage medium. The project is scheduled to begin operation early next year.

Nio Town (Nagawa Prefecture), Japan: A 1-MW (th) water-steam central receiver power plant went into operation earlier this year. The field consists of 807 heliostats, each providing 172 ft² (16 m²) of surface area; it reflects the sun's rays into a semicavity located on top of a 197-ft (60-m) tower and produces saturated steam at 480°F (2..0°C). Pressurized water is used as the thermal storage medium for 3 MWh (th) of heat storage. The project is completely funded by the Japanese Agency of Industrial Science and Technology and the Ministry of International Trade and Industry. □





Eurelios (Italy)

Themis (France)

Project Sunshine (Japan)

generation, heating and cooling, and low-temperature steam production for a nearby knitwear plant.

Line focus, or trough, systems consist of a series of specially designed cylindrical or parabolic troughs lined with mirrors to collect and concentrate the sun's radiation. Under federal sponsorship, a number of the line focus systems have been installed at industrial and research sites. These systems usually operate in the lower temperature ranges, 200–600°F (93–316°C), adequate for providing industrial process heat, for operating small turbine generators, or for some specific commercial or industrial applications. Such uses might include irrigation pumping, for example, or steam injection for secondary oil recovery. Recent EPRI analyses indicate that line focus systems, because of temperature limitations, do not look favorable for large-scale electricity production.

Outlook

After an investment of many hundreds of millions of dollars in solar-thermal conversion technology since the early 1970s, where are we now and where do we go from here? Of all the solar-thermal technologies, only one is in commercial use: flat-plate collectors for water and space heating. The others are in various stages of development.

Of those solar-thermal technologies in development, the line focus systems have the most experience in field installations. This experience has been gathered in industrial and commercial process heat applications, where the temperature requirements are lower than those of utility power generation needs.

The point focus systems are the least developed of the solar-thermal technologies, but with further development they may have the capability for utility applications because they can achieve temperatures high enough for efficient electricity generation. Because the point focus systems are modular, they hold the potential for serving a wide range of electric requirements and may lend themselves to incremental installation.

Considerable resources have been expended on the development of central receiver systems, both in the United States and abroad. The technology holds significant promise for electric utilities as stand-alone plants that contain thermal storage systems; as solar repowering units tied to existing oil- and gas-fired units; and as new solar-fossil hybrid plants. It is also significant that a number of electric utilities have become directly involved in the studies and projects conducted by both DOE and EPRI.

With the level of federal solar program support sharply decreasing and future federal involvement increasingly cloudy, the corporate commitment of funds from suppliers and utilities needed for continued development will be determined in large measure by the analysis of results of solar-thermal conversion projects in the field today. These include not only the U.S. projects but also those experiments under way abroad, whose results will now become even more crucial. As these important data are collected, the next critical step in the development of solar-thermal power will be to ensure the broad and accurate dissemination of this information. ■

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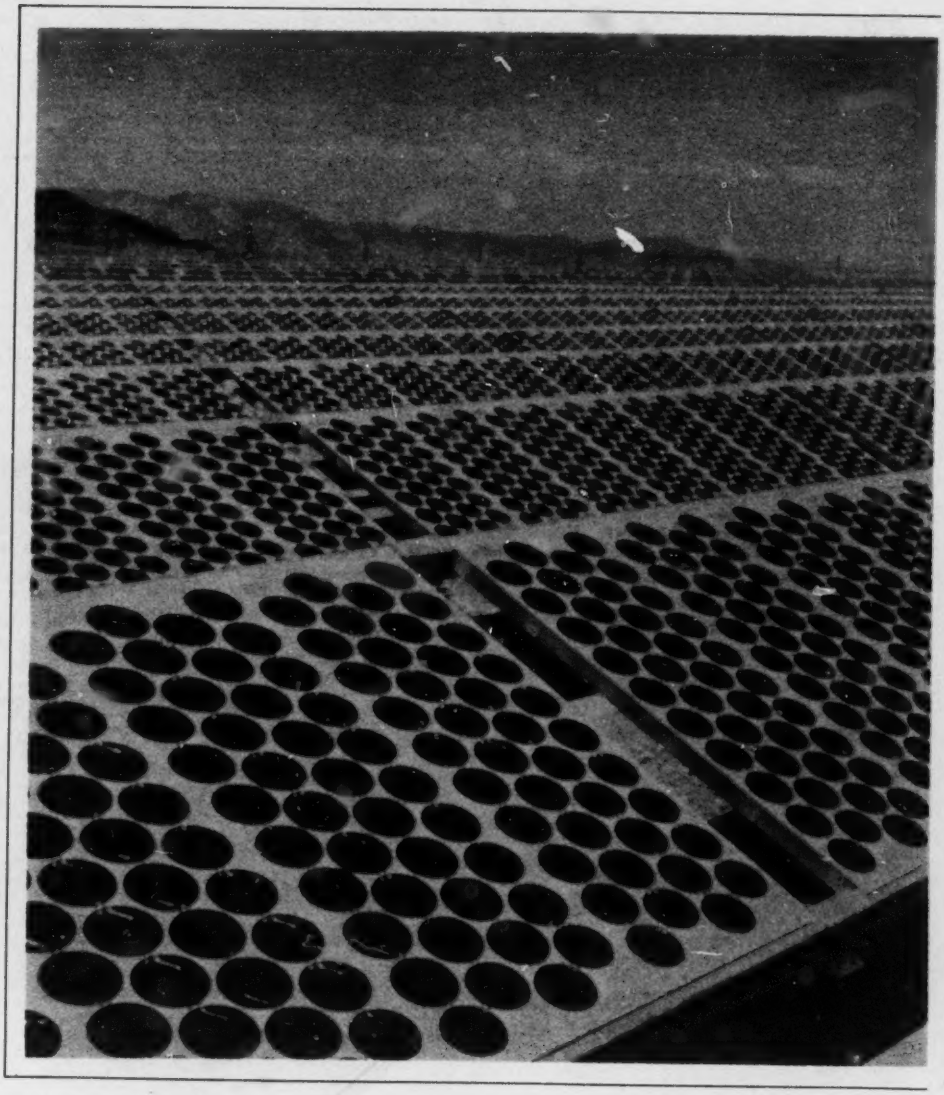
This article was written by Dan Van Atta, manager, Public Information. Technical information was provided by John Bigger, Advanced Power Systems Division.



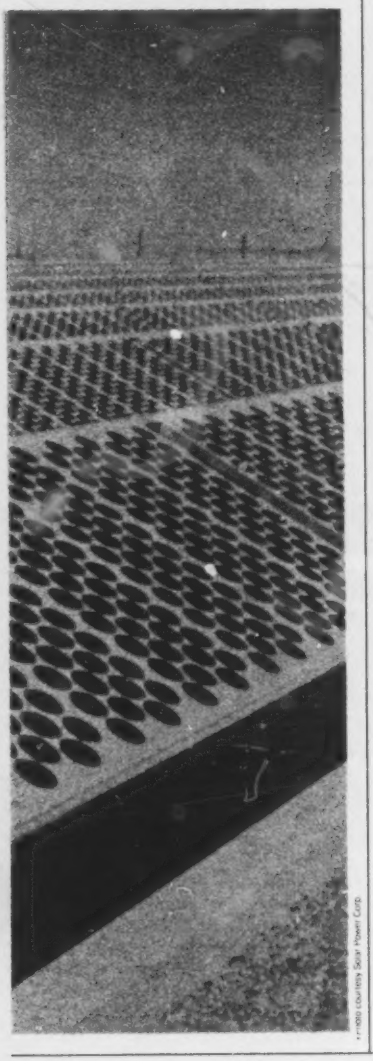


Photo courtesy Solar Power Corp.

Photovoltaics: A Question of Efficiency

Solar photovoltaic cells make economic sense today in areas remote from central station networks where the need is critical and the power requirements are relatively small. But where there is access to conventional power generation, photovoltaic arrays are not yet competitive because of low efficiency and high cost, including the cost of support structures and power conditioning apparatus. The key R&D need is to double typically available energy conversion efficiencies for photovoltaic materials. Should efficiency be improved, solar cells will become economic first for those users—electric utilities among them—who can spread the costs of large systems over a long service life.

Photovoltaic energy conversion is considered a promising technology because it produces electricity directly from sunlight without intermediate gas, steam, or mechanical cycle. It therefore appears efficient and benign. Moreover, photovoltaic electricity systems are modular—arrays of identical modules can be assembled to meet almost any power need, so it seems possible to use them even on individual house rooftops.

These attributes have fostered an image that commercial use of photovoltaic electricity is just around the corner. Manufacturers and venturers see a business opportunity. Utilities see a new way to generate power. Futurists see an inexhaustible energy resource. And reformers see modular systems that encourage decentralization and a lessening of control by corporate giants.

A small, specialized photovoltaics market does exist. Remote needs for electricity account for the annual manufacture and sale of solar cells that total some 4 MW of new generating capability. The major application is in telecommunications, for which solar cells and batteries convert and store energy to operate isolated microwave relay stations. Similar systems provide the energy for railway controls in the desert, navigation aids ashore and afloat, and communications gear on offshore oil drilling and production platforms. Power has a very high value in these remote applications, and solar cells generate it more cheaply than any other means.

But the growth of this one market is unlikely to fulfill the expectations of today's solar cell producers. There is increasing evidence that the cost of photovoltaic systems will not soon be low enough to capture the high-volume rooftop market of small consumers. If costs do become more favorable, photovoltaic systems at utility scale (at least several hundred kilowatts) are likely to be the first widespread application in which photovoltaic electricity is feasible on its own, free of tax credits or other incentives. To see why and how this is so, it is necessary to take some note of the last 10 years.

The push for lower costs

Photovoltaic energy conversion was first exploited meaningfully in 1958, when solar cells powered a radio transmitter on the Vanguard space satellite. The technology has been highly successful in space since then. It was seriously considered for power on earth when fossil fuel limits began to be seen and when the embargo of 1973 severely reduced the availability of oil from the Middle East. Federal R&D support began under auspices of the National Science Foundation in 1972 and by the 1981 fiscal year was at a level of $135 million in annual DOE expenditures for research, technology development, and field testing.

A major intention of the national effort in photovoltaics, as evidenced in project selection and funding, was to encourage an early market based on small rooftop installations. (This objective was a matter of emphasis; it would not preclude the emergence of other markets.) Although research in photovoltaic phenomena, materials, and devices was part of the program, priority was given to technology development, that is, optimizing the efficiency, reliability, and economy of solar cells made from what is called single-crystal silicon. Costs were expected to fall mainly because of the economies of mass production.

Federal planners estimated that the annual production and sale of 500 MW of photovoltaic electricity generation capacity would constitute a true commercial foothold. A unit cost target was also set: $0.70 per peak watt (in 1980 dollars) at the level of a modular package containing many interconnected cells. These volume and cost targets were seen to be interdependent and achievable by 1986.

The government push in photovoltaics R&D has been paralleled in the private sector, where funding is thought to have reached comparable levels: $100–$150 million annually. Most corporate research budgets and achievements are guarded for proprietary reasons, but much industrial activity remains evident. For example, Atlantic Richfield Co. has invested in one of the largest single-crystal silicon cell production facilities. United States and foreign oil interests are funding R&D and production facilities for cells that use thin films of cadmium and copper sulfide. Energy Conversion Devices, Inc., is working with amorphous (noncrystalline) silicon technology. In separate and differently structured transactions, the company has drawn investments from Atlantic Richfield and Standard Oil Co. of Ohio that may total $110 million. Amorphous silicon is also the subject of recent heavy R&D commitments in Japan.

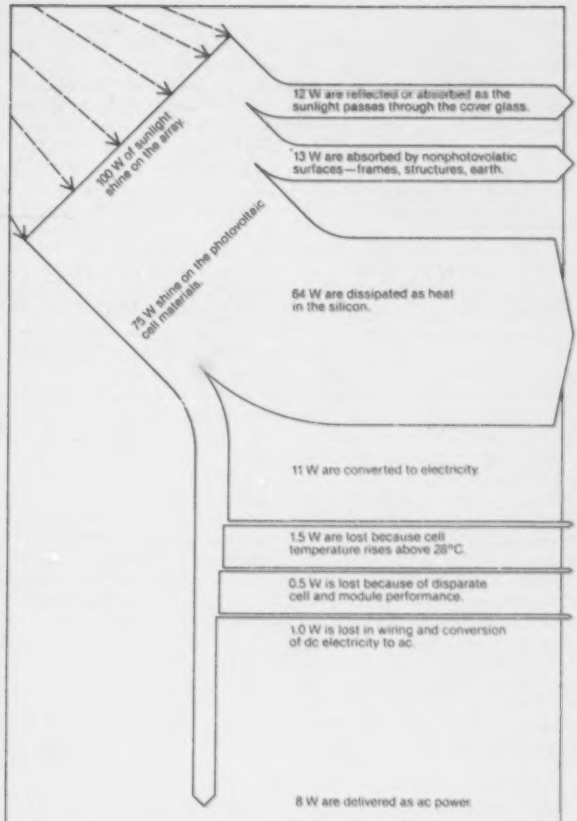
The results of development to date include good news and bad news. The unit costs have indeed come down—from the $200 per peak watt of satellite photovoltaic modules in 1959 to $22 by 1976 and to about $10 today. As a result, the specialty market for high-value remote systems is truly economic on its own.

However, the 1986 goal of $0.70 per peak watt is unlikely to be reached. Some observers feel that there are too few years in which to build annual markets and production volume from 4 MW to 500 MW. Other observers assert that the costs of silicon and its processing will always be too high for overall module costs to fall to $0.70 per peak watt. Faced with diminishing returns in cost reduction for single-crystal silicon, the photovoltaics community is looking more intently at R&D prospects in other materials and techniques.

Performance in the real world

Photovoltaic behavior is the generation of voltage (electric potential) in a material when it absorbs light. Because the energy content of solar radiation varies with its wavelength, R&D is being performed to find which photovoltaic materials are most sensitive to the wavelengths that carry most of the sun's energy.

The most common solar cell (like the most common semiconductor) begins as


100 W of sunlight shine on the array.
12 W are reflected or absorbed as the sunlight passes through the cover glass.
13 W are absorbed by nonphotovoltaic surfaces—frames, structures, earth.
75 W shine on the photovoltaic cell materials.
64 W are dissipated as heat in the silicon.
11 W are converted to electricity.
1.5 W are lost because cell temperature rises above 28°C.
0.5 W is lost because of disparate cell and module performance.
1.0 W is lost in wiring and conversion of dc electricity to ac.
8 W are delivered as ac power.

Losses in six main categories reduce the overall efficiency of photovoltaic energy conversion. The figures shown here are representative of today's nonconcentrating silicon system performance.

In general, the largest loss categories offer the most room for improvement, so they are the major topics of R&D. Cell loss is deceptive, however. For the 75 W entering the silicon, the 64-W loss (and 11-W output) results from a 15% conversion efficiency. Even silicon's maximum theoretical efficiency of 22% would entail a loss of 58 W. To do better requires photovoltaic materials and configurations that react more effectively to a greater range of the solar energy wavelengths.

highly refined silicon, solidified as a single-crystal ingot by slow withdrawal of a "seed" from molten silicon. Thin wafers are then cut and polished (with the loss of nearly half the material), and a pattern of one or more chemical elements is introduced into the wafers, each of which becomes an individual photovoltaic cell. When a cell absorbs light, electrons are freed, and the chemically defined regions in the silicon channel their flow. An electric current is produced when the flow of electrons is conducted into an external circuit.

A single such cell—some 3 in (7.6 cm) across and 300 μm thick—may represent 0.5 V and generate about 1 W. Cells are connected in series to build up the voltage or in parallel to build up the current. A module combines many cells into a package about 4 ft (1.2 m) square. Modules and panels (made up of several modules) are the customary design units for assembling photovoltaic arrays that will meet specific power or energy requirements.

Efficiency is a useful way to compare different kinds of cells and to compare cells with modules, with arrays, and with entire systems. Efficiency is the ratio of the electric power output of a solar cell, module, or array to the power content of the sunlight over its entire surface area. Outputs are measured and efficiencies are compared under standard (peak-watt) conditions: a solar intensity of 1000 W/m^2 and a cell temperature of 28°C.

Using this yardstick and under these rather idealized conditions, today's best single-crystal cells yield efficiencies of 16–17%. Modules of typical mass-produced cells seldom exceed 10%, according to Roger Taylor, project manager for photovoltaics in EPRI's Solar Power Systems Program. And he adds that well-designed systems are getting only 5 to 8%. Taylor goes on to explain why efficiency falls when components are successively connected and put to use.

"One reason is the mismatch loss. This results from the inability to make all cells truly identical. There's one least-efficient

cell in any string, and it limits the value for the whole string. There are mismatch losses within modules and between modules as they're hooked up in arrays.

"Another source of loss," says Taylor, "is the packing factor. Many cells are circular, so there are spaces between them—as well as the surface of exposed framing—that get sunshine but don't produce any electricity. Rectangular cells in advanced modules minimize this loss, of course. There are also electrical losses through the system wiring and in the equipment that converts dc electricity to ac.

"One major loss has nothing to do with how cells and modules are connected," Taylor concludes. "It really is a derating caused by higher temperature. The standard lab measurement of efficiency is at 28°C, but in the real world, cells are more likely to operate at 50–60°C, and this cuts one or two percentage points off any cell efficiency."

R&D directions

The Solar Energy Research Institute and DOE's national laboratories conduct and sponsor R&D in photovoltaics, with the principal program management in technology development furnished by Jet Propulsion Laboratory, California Institute of Technology. A few examples represent current R&D avenues, both in silicon technology and in new photovoltaic device research.

Solidifying single-crystal silicon in sheets avoids the material waste that occurs when wafers are sawn from ingots. The technique may be economical if sheets can be made wide enough to achieve production rate goals for total cell area. An alternative would be faster withdrawal rates from the molten silicon, but this tends to cause thermal stress and cracking because the sheets cool quickly.

Silicon with many crystals is another candidate for making low-cost sheets, but the grain boundaries reduce voltage and impede current flow. One remedy being investigated is a hydrogen plasma treatment that makes the boundaries electrically invisible.

Thin film devices (as little as 2 μm thick) are one advanced R&D approach. The base is a cheap substrate, and there is only enough active material for the photovoltaic response to occur. Thin-film R&D is investigating a wide range of chemical compounds in various combinations, among them indium phosphide, cadmium sulfide, copper indium selenide, gallium arsenide, and amorphous silicon.

Grain boundaries also tend to reduce the performance of thin-film cells, but precisely controlled melting and resolidification of the surface material may significantly improve its electrical properties by increasing the size of individual grains. This technique is called laser recrystallization, and EPRI is funding Poly Solar, Inc., to test it on several thin-film materials.

Unlike other thin films, amorphous silicon has no crystalline structure, but its random atomic arrangement limits current flow even more than do grain boundaries. Here, as with crystalline silicon, hydrogen treatment shows promise for overcoming the limitation.

Photovoltaic cells for use in concentrated sunlight are the other major area of advanced R&D. Concentration brings obvious advantages. With more power input and output at each cell, fewer cells are needed and higher cell costs become affordable. In addition, cell efficiency tends to improve with concentration, further reducing the number of cells. Higher efficiency also permits a smaller array of the mechanized optical elements used to track the sun.

But there are countering losses and costs. Concentrators are effective only with direct solar radiation. The optical elements exact a toll of as much as 15% of available solar energy. And high power concentrations in solar cells are accompanied by electrical losses related to the elevated currents and temperatures involved. Concentrating mechanisms cost more than do the supporting structures for equivalent flat-plate photovoltaic arrays. If concentrating systems are to be economic, their cell conversion efficiencies must considerably exceed those in flat-plate systems.

EPRI is funding Stanford University research on silicon cells for use at a concentration of about 500 suns. Models of performance indicate that cell efficiencies of about 25% could be achievable. This work stems from earlier funded development of a thermophotovoltaic system, in which even more highly concentrated sunlight is absorbed by a refractory element that gets very hot and reradiates the transmitted energy at wavelengths more efficiently converted to electricity by silicon cells. It now appears that a system with the new concentrating cells—using sunlight directly—can attain efficiencies sufficiently close to those projected for the thermophotovoltaic system, but without the materials problems associated with its 1900°C temperatures.

Conversion efficiencies even higher than 25% may be possible in multijunction (or cascade) devices, where different portions of the solar spectrum are converted to electricity in different regions of the device, each operating at its most efficient point. Such cells are the subject of both government and private sector research.

Analyzing value and cost

For seven of the past nine years of intensified nationwide work in photovoltaics, EPRI has selected research projects that complement the federal effort. The Institute has become closely involved with the scientific community in photovoltaics, thereby gaining a solid basis for assessing the state of the art.

Most important to the utility industry are EPRI's economic feasibility studies of photovoltaic energy conversion that flow from such assessments. For example, higher efficiency is the mark of technical progress in components. It is also a meaningful index of economic feasibility because of how it reduces the area-dependent costs of a system. The ques-

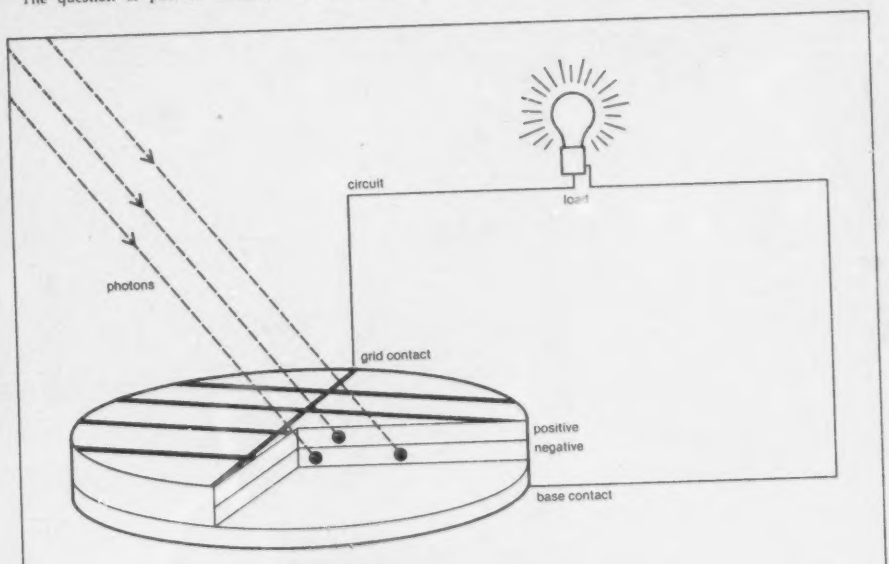
tion therefore arises: What efficiency is possible?

The theoretical maximum in single-junction devices (without concentration) is about 22% for silicon and as much as 27% for some other materials. Both values are nearly twice what is being produced today, leading Taylor to observe, "This is one reason people are interested—there's so much room for improvement."

The question of possible efficiency necessarily begins at the level of a cell and proceeds to the level of a system. It is perhaps more relevant to ask: What efficiency is required? The first answers are found at the level of an entire system, in terms of its value to an electric utility.

Value analysis is the way a utility determines the most economic way to handle system load growth. The daily pattern of forecast load is considered, and for that pattern the costs are estimated for electricity produced by existing and by new generating units that might be operated in various combinations. Each kind of unit has its own characteristic reliability, yielding a frequency and cost of outage time and consequent requirement for replacement power from yet another generator (with its own attendant costs).

By these analyses, it is possible for a utility to rank prospective generating op-



Photovoltaic energy conversion begins with photons, the increments of energy that are carried in all wavelengths of light. Photovoltaic conversion is completed when current flows in a circuit connected to the opposite sides of a solar cell.

The essence of a cell—whether treated silicon or molecular films of selected materials—is its two regions, one electrically positive and one electrically negative. Solar photons dislodge electrons from their chemical bonds in the cell materials. The positive and negative regions encourage electron flow, and contacts on the cell surfaces channel this flow into a circuit.

Photons in the longer wavelengths of sunlight are too weak to dislodge electrons. Photons in the shorter wavelengths dislodge electrons and have energy left over. This unexploited photon energy limits the efficiency of photovoltaic energy conversion.

Electricity from solar photovoltaic arrays is finding application in remote corners of the world—from land-based communication relay stations to sea-based platforms—wherever access to conventional power networks is impractical and power requirements are relatively small.

tions by the economic benefits they produce. Within the electric utility context, peak-period electricity generated by oil-fired power units is the most expensive energy today. It is therefore the market target of all new solar power technologies.

Balance-of-system costs must be subtracted from system value to arrive at permissible costs for the photovoltaic components alone. Today's photovoltaic systems of intermediate size (1–500 kW) cost about $30,000/kW. Two-thirds of this, about $20,000/kW, represents costs for nonphotovoltaic apparatus. Even in systems of the future, it is expected that half the cost will be for the balance of the system. Photovoltaic array area increases directly with power level, so there is little economy of scale for components that are area-dependent, such as foundations, structures, and wiring. Their cost per unit of area, or of power output, will not change much in systems beyond several hundred kilowatts. Other components are not area-dependent. They are related only to power level, and their costs per unit of power output fall as system size increases. Examples are the equipment for dc-to-ac power conditioning and connection to a utility grid.

During the next several years, balance-of-system items and their costs will be a major focus of R&D under EPRI's Solar Power Systems Program. The objective is twofold: to find out how (and how much) these costs can be reduced and to better understand their influence on the requirements for photovoltaic devices.

Efficiency as a cost cutter

When the lowest unit costs have been achieved for balance-of-system items, the only remaining way to reduce their effect on system cost is to cut the system area. This means higher photovoltaic efficiency is needed. Efficiency figures for modules are most useful as goals and in comparisons of performance because the module is the basic component assembled and sold. Individual cells may vary, and the performance of a module shows how they average out. But system photovoltaic efficiency figures are most useful in overall economic analyses.

Efficiency requirements may be established for utility components accordingly. But other reasoning explains why photovoltaics will become attractive to utilities sooner than to any other sizable market. A given level of technology sophistication, with its associate system efficiency and cost, will first become saleable for the manufacturer when applied to large (utility scale) systems. It is mainly a matter of large-lot factory-direct pricing compared with single-unit retail pricing. Markups are minimized because some product distribution steps (and their costs) are avoided.

Also, the 25–30-year time spans of utility planning and costing practice contrast sharply with the 3–5 years into which other users must shoehorn their recovery of photovoltaic system costs. Together with economies of scale and of large factory-direct purchases, life-cycle costing suggests that utility photovoltaic applications will be attractive sooner than a rooftop retail market.

Current technology does not yet permit a utility market to take shape. Costs are still too high. If relief is to be found, it must be in higher device and system efficiencies, that is, in further research.

Thus, the foreseen large (and early) end-use market for photovoltaics is not emerging. Instead, photovoltaic systems at a scale of interest to electric utilities are likely to be the first significant volume sold. Those systems probably will not be based on the technology of flat-plate single-crystal silicon modules. Their economic viability will depend—among other things—on improved efficiencies and lower costs that have yet to flow from the R&D laboratory.

Will this progress in photovoltaics R&D actually be made, or will cuts in the federal program be fatal, not just by their own severity but by discouraging private sector research as well? EPRI's outlook is guardedly positive. Of all the renewable energy resource technologies, photovoltaics may have the best chance for success with only limited government R&D funding. This is true during the research (as opposed to development) phase because the principal need is for laboratory experimentation with photovoltaic materials and device configurations. Also, semiconductor and computer industry research involves extensive investigation of similar materials and surface physics, as well as of production technologies. It is reasonable to anticipate relevant advances from that quarter. Photovoltaics R&D thus seems to have its own momentum.

Moreover, the modular nature of photovoltaic systems suggests that there never need be large demonstration plants and the funding to match. Performance, reliability, and economic prospects can be authenticated at the scale of a few megawatts. On these bases, photovoltaic energy conversion continues to have potential as a commercial producer of bulk electricity. Just around the corner, perhaps, but it looks like a long walk to the end of the block.

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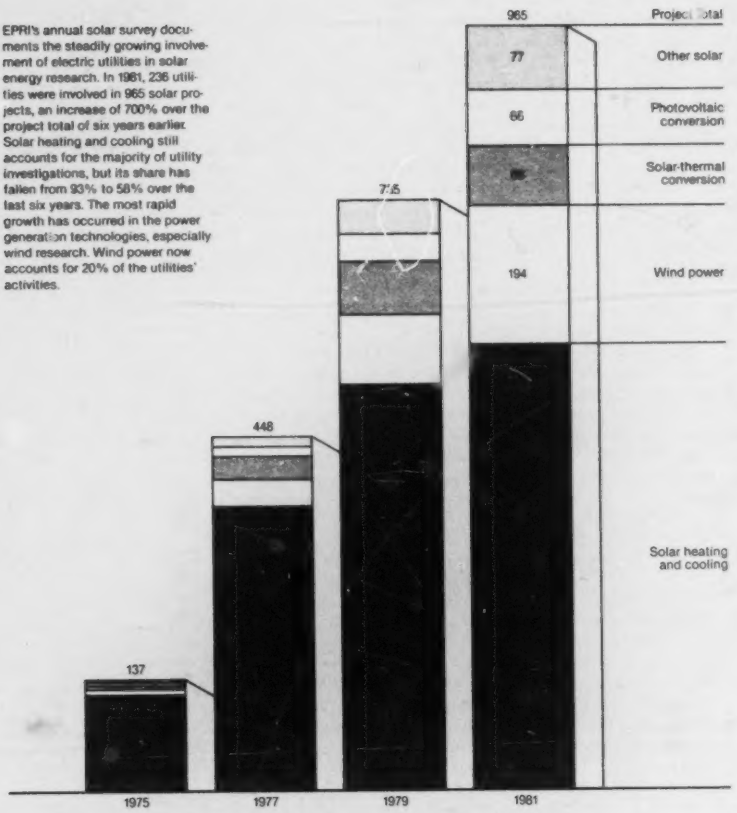
This article was written by Ralph Whitaker, feature editor. Technical background information was provided by Roger Taylor, Advanced Power Systems Division.

BRIEF

Utility Solar Survey

EPRI's annual solar survey documents the steadily growing involvement of electric utilities in solar energy research. In 1981, 236 utilities were involved in 965 solar projects, an increase of 700% over the project total of six years earlier. Solar heating and cooling still accounts for the majority of utility investigations, but its share has fallen from 93% to 58% over the last six years. The most rapid growth has occurred in the power generation technologies, especially wind research. Wind power now accounts for 20% of the utilities' activities.



BRIEF

Squeezing More From Hydroelectric Power

One renewable energy resource—hydroelectric power—was developed decades ago; it is the nation's third-largest source of electric energy, and it is expected to expand in the immediate future as its relatively inflation-proof economics become increasingly attractive. In 1980 hydro produced 12% of the nation's electric energy, right after coal (50%) and natural gas (17%), but just ahead of nuclear (11%) and oil (10%) and far outdistancing solar, wind, and geothermal.

Hydro was first used to generate electricity in the 1880s, but by the 1940s large central plants fired by fossil fuels produced lower-priced power, and interest in small hydro receded. In the 1970s increases in the price of power from oil and other conventional fuels prompted electric utilities and others to reassess hydro.

Of course, the choicest hydro sites have already been taken, and many other potential sites have long since been claimed by dams built for other purposes or have been set aside for preservation of the natural environment. But existing dams and powerhouses can be redeveloped to yield more generating capacity, and nongenerating dams used for water management can be retrofitted to produce electricity as they continue to carry out their original functions. Redevelopment spares the costly construction of new dams and powerhouses. New engineering techniques and ways of minimizing environmental effects will also permit carefully designed hydro plants to be built at sites once considered unfeasible, such as smaller sites.

Many groups, including EPRI's Energy Management and Utilization Division, are now investigating the potential of both low- and small hydro installations (*EPRI Journal*, December 1980). Hydro's biggest booster has perhaps been the National Hydroelectric Power Study, authorized by Congress as part of the Water Resources Development Act of 1976. The U.S. Army Corps of Engineers was to inventory existing and potential hydro sites, estimate hydro demand and potential, and identify the economic, environmental, and institutional obstacles to its development. Initially, the study identified over 60,000 potential hydro sites, including existing dams and undeveloped sites. Subsequent screening reduced the final inventory to approximately 2100 potentially feasible sites, which could add up to 57 GW of capacity to hydro's current 73 GW and add an annual energy potential of 149,000 GWh to the current contribution of roughly 280,000 GWh. About 40% of the additional capacity would be at existing dams. Bearing out the renewed interest in hydro, the Federal Energy Regulatory Commission's permit applications for exclusive preliminary evaluation of hydro sites increased from 25 in 1978 to over 1200 (for nearly 20 GW) in 1981.

EPRI's recently instituted hydro research is taking a number of approaches to hydro development and is trying to improve plant availability, plant output, and the economics of small hydro. To assist utilities in determining the economic viability of numerous potential hydro sites, EPRI has prepared a simple, inexpensive method for preliminary site screening that will permit users to inventory possible sites, analyze their potential, rank them in order of feasibility, and determine those that merit further investigation. As the price of power from oil, gas, coal, and uranium rises, more and more utilities may discover hydro's new potential. □

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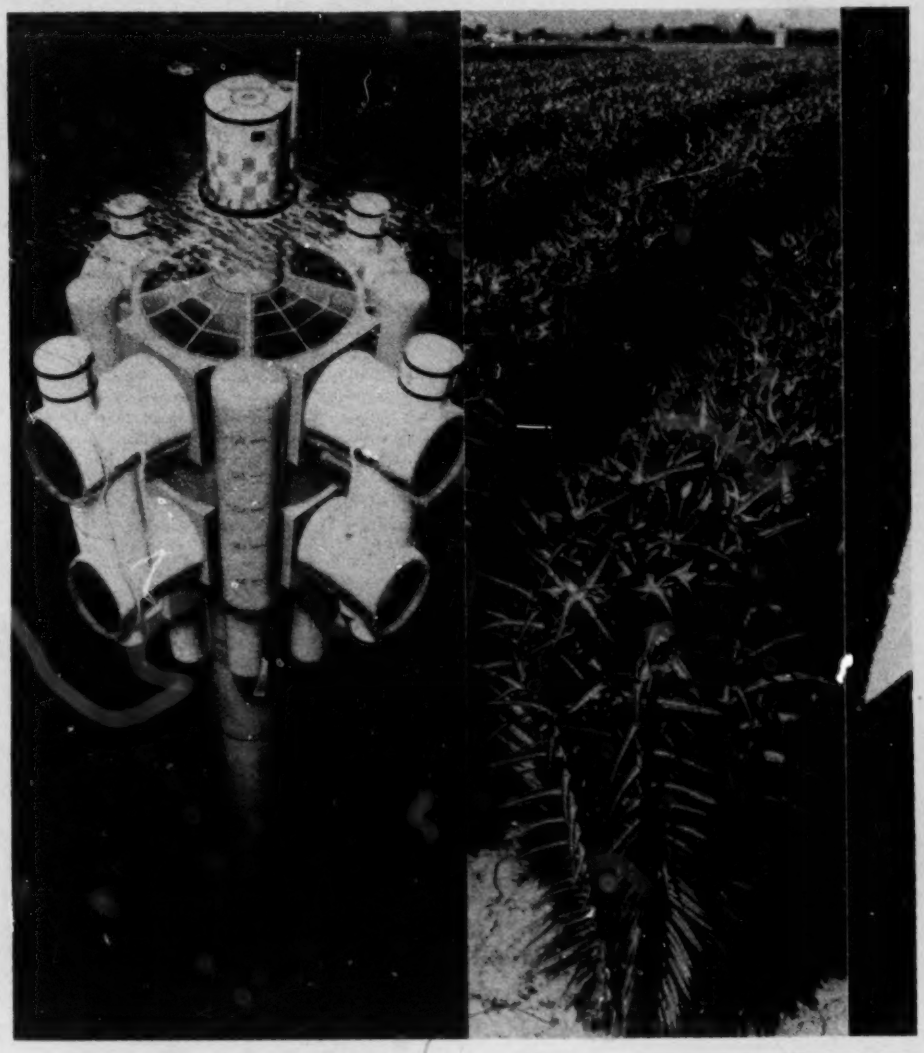


Sea, Soil, Sky: Testing Solar's Limits

Gigantic heat exchangers for ocean-thermal energy conversion, vast plantations harvested for fuel, and massive arrays of photovoltaic cells in geocentric orbit have captured conceptual fancy in recent years. But the facts emerging from engineering assessments and the limitation of federal support point to lower priority among the R&D options. For the foreseeable future, greater emphasis will be placed on less grandiose schemes, such as forest and agricultural waste combustion and municipal refuse, which may have significant local impacts.

Biofuel processes, ocean-thermal energy conversion (OTEC), and satellite power systems are electricity generation technologies that could be feasible sometime in the twenty-first century. Apart from wood combustion, which is already a familiar biofuel system, these types of solar technologies are still in the early stages of development and affect most utilities little at present. Nevertheless, utilities need to be aware of the status of these concepts in planning long-term R&D for potential generating options.

Biofuel applications that make sense, such as wood waste combustion, have been in use for decades. But they require a guaranteed feedstock supply and, if a multiparty operation, call for mutually beneficial business arrangements.

OTEC and satellite power systems are intriguing technologies in theory, but in light of the magnitude of development problems, the size of required systems, and limitations in market penetration, the question arises of whether electric utilities should share in underwriting the risks associated with the development of these technologies.

Biofuels

The burning of wastes and residues to produce electricity or process steam is already a well-established practice in the forest products industry, which satisfies about 50% of its own energy needs by burning mill wastes. This currently represents about 1.5 quadrillion (1.5×10^{15}) Btu, which is about 2% of the total annual U.S. primary energy supply of 80 quadrillion Btu.

Several electric utilities, too, have taken advantage of local supplies of wood waste. For instance, Northern States Power Co. fuels its 25-MW peaking plant at Red Wing, Minnesota, with lumber mill wastes. Two boilers, originally fired on coal only, are fed a fuel blend of 80% coal and 20% (by weight) sawdust, wood chips, and bark. The utility has made no significant changes in equipment to accommodate biomass, and in two years it has experienced no operational problems, deposits, emissions, or corrosion beyond those typical of firing coal. The only additional processing required is t'ending the coal with the biomass, and this higher cost of handling is offset by the lower price of locally available wood waste: $0.5–$0.6/million Btu, as opposed to $1.5/million Btu for coal delivered to the site.

Some other utilities that have found it financially beneficial to burn wood wastes are Burlington Electric Dept. (Vermont), Eugene Water & Electric Board (Oregon), Grand Haven Board of Light & Power (Michigan), and Lake Superior District Power Co. (Wisconsin).

The two major requirements for making wood combustion an economic option are guaranteed supply and minimal transportation costs. Regarding supply, long-term supply contracts, such as those that utilities establish with coal and oil companies, are difficult to obtain because of seasonal and market variations. Also, biomass supplies can easily be affected by bad weather or plant disease. With regard to transportation, if the wood has to be collected and trucked from several distant locations, the fuel may not be worth the cost of transportation. The energy content per unit weight of wood is half or less that of good-quality coal because moisture content is higher and the density of material is lower. Hence, the transportation cost for wood per unit of energy may be double that for coal. For these and other reasons, commercial wood-burning power plants tend to be limited in size to 10–50 MW.

These two factors—guaranteed supply and transportation—are crucial to the feasibility of other types of biomass as well, such as wheat straw, oil-seed crops, and fast-growing trees like eucalyptus and alder that could be cultivated in the future on energy farms.

The question remains of whether it will be socially acceptable to use land, water, and fertilizer to produce crops for fuel rather than for food, feed, or fiber. Two potential solutions might be to limit biofuel production to plants like the creosote bush that will grow in arid conditions and poor soil and/or to select plants like sunflowers that can be used as food and feed as well as fuel.

Finding plants suitable for cultivation as electric utility fuel will take years of research. One EPRI contractor, the University of California at Davis, experimentally determined that *Euphorbia lathyris*—a desert plant—produced an inadequate harvest in the arid conditions it was thought to enjoy. A long-term solution to problems of this sort may arise from basic research on genetic engineering, in which test-tube plants are developed specifically to enhance the characteristics most important for their effectiveness as a fuel. However, it is unlikely that the efficiency of photosynthesis can be increased considerably, so the energy contribution from biofuels is unlikely ever to exceed a few percent of national needs.

Another possibility for the future is the development of other processes for using biomass, namely, conversion to combustible liquids, gases, and other solids (e.g., charcoal). Two categories of processing are being tried: thermochemical and biochemical.

The thermochemical processes—pyrolysis and gasification—involve heating the biomass. Pyrolysis, heating in the absence of air, is generally a lower-temperature process that forms gases, liquids, and solids; gasification, a higher-temperature operation that takes place in the presence of an oxidant (e.g., air), principally produces gaseous fuels.

The biochemical processes are all fermentations, that is, microbial transformations of organic feed materials that take place without oxygen and produce alcohols and organic chemicals, such as methane, ethanol, acetic acid, and acetone.

Before biomass can be processed thermochemically or biochemically, it must be prepared, whether reduced to small chips, dried, compressed, or treated with enzymes or acids. Such pretreatment increases the cost of the end product.

Wood wastes from Weyerhaeuser Co.'s pulp and paper factory (rear) are burned to produce steam. In this cogeneration facility, the steam is first routed to drive the turbine generators for Eugene Water & Electric Board (foreground) and is then directed back to Weyerhaeuser's manufacturing process.

OTEC takes advantage of the temperature difference between surface and deep waters to drive turbine generators. The government test facility, OTEC-1, was built by TRW, Inc., and Global Marine Development. Mini-OTEC was backed by the state of Hawaii, Lockheed Missiles & Space Co., Inc., Alfa-Laval Thermal, Inc., and the Dillingham Corp.

Production of fuels by these processes also raises the question of market competition: If a fuel derived from biomass is clean-burning and produced in a liquid or gaseous form, will it not be preferentially drawn into the transportation market rather than the utility market?

In addition to plant-derived biofuels, manure, sewage, and municipal solid waste could become sources of energy for electricity generation. However, the amount of the resource is small from an electric utility standpoint, and institutional barriers may exist. For example, several independent parties may be involved: the electric utility itself, the city government, the sanitation company, recycling organizations, farmers, and individual homeowners. Historically, it has been difficult to define program objectives that meet the needs of all parties involved.

The applications that are emerging for biomass, manure, sewage, and municipal solid waste are basically regional ones. Although these resources may never contribute more than a few percent to the U.S. primary energy supply, local or regional situations may exist where it makes economic and technical sense for these resources to provide a portion of a utility's fuel needs. EPRI will continue to monitor technological advances in these fields to permit utilities to apply these concepts to their local situations when feasible.

Ocean-thermal energy conversion (OTEC)

The concept of generating electricity with OTEC systems takes advantage of the approximately 40°F (22°C) temperature difference between the surface and the depths of tropical, subtropical, and equatorial ocean waters. Because the United States has a limited warm water resource and because the ratio of coastal area to inland area is small, relatively few U.S. electric utilities have shown an interest in this technology.

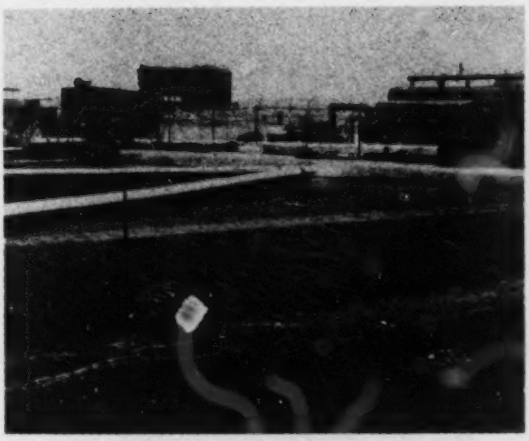
However, two basic designs have been investigated: closed cycle and open cycle.

In the closed cycle, warm surface water is drawn into the system to heat a working fluid, such as ammonia. The liquid ammonia vaporizes when its temperature reaches about 60°F (16°C) and expands to turn a turbine generator; after it has passed through the turbine, it is condensed back to liquid form by cold water drawn from the ocean depths through a huge vertical pipe.

The open cycle requires no working fluid or heat exchangers. Instead, surface water is flashed to steam in a partial vacuum. The steam drives a turbine generator and is then condensed by cold water from the depths. With minor modifications to this system, the open-cycle design can provide fresh water as a by-product.

A characteristic of both open- and closed-cycle systems is that they are extremely inefficient in terms of energy conversion because the temperature difference on which their operation is based is very small. For this reason, OTEC systems must be built to enormous proportions if they are to generate enough electricity to be economically worthwhile. Comments David Jopling, coordinator of research and development for Florida Power & Light Co., "To my knowledge, there is no electric utility, no architect-engineer, no equipment manufacturer, and no vendor presently in the electric power business that has any direct experience with the design, construction, operation, and maintenance of facilities of the magnitude of size that OTEC is proposing to operate." He adds, "I'm not saying it can't be done; I'm just saying it hasn't been done."

Before any commercial-sized system can be contemplated, heat exchangers larger than any that now exist must be designed. Pumps capable of moving a vast amount of water will be needed; for example, a 100-MW OTEC plant would have a water flow comparable to that of Boulder Dam. Cold water pipes measuring 3000 ft (900 m) long and 100 ft (30 m) across must be designed, fabricated, and installed in the ocean environment. Such pipes are far larger than any yet made.



Solar salt ponds operate on a principle similar to that of OTEC. The sun's heat passes through the top, freshwater layer of the pond and concentrates in the lower, salty layer. Ormat Turbines of Israel has operated test ponds for several years.

Near St. Malo in Brittany, France, a 240-MW tidal power plant spans the River Rance. Because tides do not give a constant water flow, the plant can produce power only about 25% of the time.

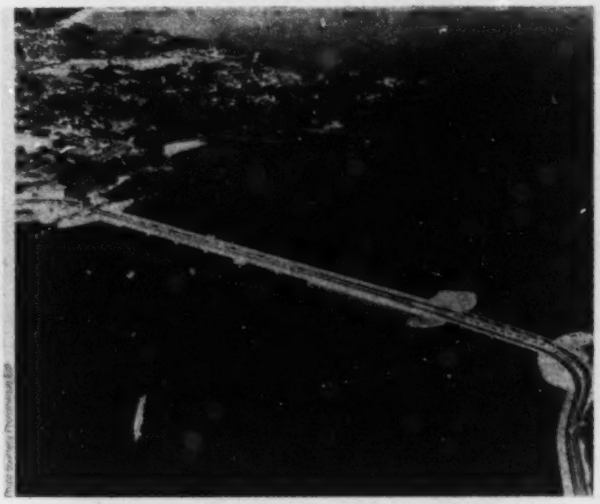


Photo courtesy Photoworld/EDF

The entire system, whether shaped like a ship, a sphere, or an oil rig, must be moored or otherwise kept in position in depths at which no vessel has ever before been stationed.

In addition, no turbines of 10 MW or larger are available that operate at the low pressures OTEC systems demand. Moreover, the design, manufacture, and deployment of the cable required to carry electricity to shore must be better understood. For example, the portion of cable leading directly from the OTEC plant to the ocean floor would be subject to severe stresses from sea currents and eddies in addition to those caused by its own weight.

In fact, the entire OTEC system would have to be able to withstand severe storms over many years, corrosion by salt, erosion by the constant movement of fluids, and biofouling caused by growth of algae and encrustation of barnacles and other marine life.

An alternative to the stationary system concept is the OTEC plant ship, which avoids the complexities of cabling electricity to shore and also enables the OTEC system to move seasonally to locations of warmest surface water. In the plant ship, the electricity generated would power equipment for processes to produce such chemicals as ammonia.

The grazing plant ship (so named for its probable speed of 0.5 knots) could also be designed for on-board processing of energy-intensive products like aluminum, magnesium, nickel, various alloys, or semiconductor materials. Or the ships might even serve as mining platforms for extraction of manganese, copper, cobalt, and nickel from the seabed.

As yet, only the stationary system has been tried—stationary in name only, as both demonstrations (one a DOE effort and the other a private-industry system) are cradled in converted ships.

The federal OTEC program was born in the early 1970s, when ocean energy systems were selected as one of a group of six options for investigation in terms of their potential for reducing the nation's dependence on imported oil. The DOE test facility, OTEC-1, was built by TRW, Inc., and Global Marine Development and installed on a 26,000-ton converted tanker, which was first moored 18 miles (29 km) off Kawaihae Harbor, Hawaii, in July 1980.

The research aims were to prove heat exchanger performance and thermal efficiency and to assess levels of corrosion and biofouling. The system was a closed-cycle operation incorporating a 1-MW titanium tube-and-shell heat exchanger, which could simulate 10 MW of capacity. It had three cold water pipes, each 2800 ft (853 m) long and 4 ft (1.2 m) in diameter, and the deepest ocean moor in the world (4000 ft; 1219 m). The system did not include a turbine, however, and therefore could not generate electricity. It has now been retired, and federal funding for overall OTEC R&D in FY82 is uncertain.

"The next step would have been a totally integrated system," says Carmen Castellano, DOE project officer in the Division of Ocean Energy Systems. "A pilot plant in the mid-1980s that would be the real baseline to which utilities could look and say, 'Yes, it's real,' or 'No, we don't believe it.'"

Island markets, where the OTEC resource base is comparatively large in relation to energy needs and where the population is mainly if not wholly dependent on oil-generated electric energy, represented DOE's first target: Hawaii, Puerto Rico, the Virgin Islands, Guam, American Samoa, and others.

The second OTEC demonstration, Mini-OTEC, was cooperatively supported by the state of Hawaii; Lockheed Missiles & Space Co., Inc.; Alfa-Laval Thermal, Inc.; and the Dillingham Corp. at a cost of about $3 million. The demonstration took place between August and November of 1979 off Keahole Point, Hawaii, and produced between 12 and 15 kW of net power (50 kW gross). A converted U.S. Navy scow housed the equipment, which included a titanium-plate heat exchanger and a cold water pipe 2170 ft (661 m) long and 2 ft (0.6 m) in diameter. This project provided a working test of the concept and was believed to be technically successful in that the performance was comparable to predictions.

Despite these results, it is a fact that the only areas in the United States that have the appropriate differential in water temperatures, in addition to being close enough to land for transmission purposes, are the upper Gulf of Mexico and the lower eastern coast of Florida. Because of this limitation in suitable geographic locations, a relatively small number of U.S. electric utilities could benefit from OTEC generation in terms of the baseload capacity increment on their systems.

In addition to the United States, a number of nations have been active in OTEC research: Japan, France, Sweden, the Federal Republic of Germany, and the Netherlands. The island nation of Nauru near the equator in the central Pacific has entered into an agreement with the Japanese to build a 100-kW land-based system. With a larger OTEC system, the island might eventually become an attractive site for energy-intensive industries.

Solar ponds, waves, and tides

Solar ponds work on a principle similar to that of OTEC, but here the temperature difference that makes electricity generation possible exists between a layer of highly concentrated salt water and a layer of fresh water that floats on its surface. The sun's heat passes through the freshwater layer, which does not warm up significantly, and is trapped in the salty layer, which can reach about 200°F (93°C). Heat exchangers, pumps, and turbine generators are used in much the same way as in an OTEC system.

Southern California Edison Co. and Ormat Turbines of Israel are studying the feasibility of building a 5-MW demonstration plant at the Salton Sea, California, and eventually developing a 600-MW commercial generating facility. Ormat has operated test ponds in Israel

for several years and is currently constructing a 5-MW facility there.

The Tennessee Valley Authority is also constructing a solar pond for research purposes near Chattanooga, Tennessee. TVA hopes to demonstrate that the pond, which should be fully operational by summer 1982, can provide heat at a sufficiently high temperature to permit electric power generation.

Although ponds may have appeal in special applications where appropriate conditions already exist, such as a supply of brackish water and a sunny climate, their requirements for land area and the availability of water and salt make them unlikely to contribute in large measure to the national energy supply. Because of the low energy density of solar radiation, an extensive collecting area is necessary. For example, assuming solar radiation at the world average, about 2800 ft² (260 m²) of water are required in order to replace one barrel of oil a day—if the collector is 100% efficient. Efficiencies are in fact very much lower; therefore, far larger areas of water are needed. In addition, about one-third of a ton of salt must be added to every square meter of pond. In building a solar pond, provisions must be made to prevent leakage, both of the solution from the bottom of the pond and of heat into the ground.

Although these types of losses present a real challenge for the development of solar ponds, such problems seem minor when compared with the potential loss of entire generating systems that depend on waves and tides. The unforgiving ocean environment is extremely hard on machinery and could actually destroy generating equipment.

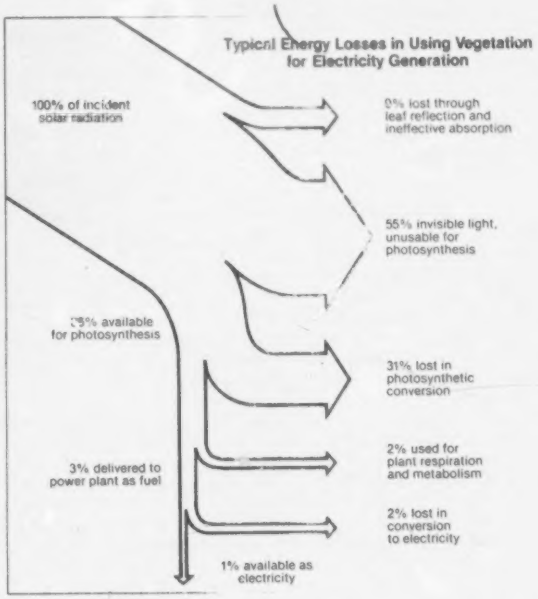
Coastal and deep-ocean wave power has been studied, particularly in Great Britain. Wave power along our North Atlantic coast, which may have the highest annual energy potential of all U.S. wave resources, is estimated to average about 10 MW per mile of shoreline. If a fifth of all this energy could be converted to electricity, the effective supply would be 2 MW per coastal mile. Considering that 500 miles of coastline equipment would be needed to generate enough power for a million households, this would not seem a practical concept.

Deep-ocean wave energy may be 5–10 times greater than at the coastline. However, as with OTEC, collecting wave energy in the deep oceans presents extremely harsh conditions for a plant, its mooring mechanism, its transmission line, and its operating crew. Nevertheless, several countries have built devices to harness wave power. Japan probably has the largest, an 80-m-long ship's hull, in which 20 turbines are powered by oscillating columns of air and water. During two years, the system has produced up to 150 kW of electricity. It is believed that output could be increased by a factor of 10 with some redesign.

As an energy resource, tide power is difficult to harness; it is not constant, nor does it occur on a regular daily schedule because of the orbit of the moon. Only a few locations in the world have a daily tidal range (the difference in sea surface height from high tide to low tide) great enough to justify the huge cost of building a dam to generate electricity.

One of the few suitable sites is Passamaquoddy Bay, an arm of the Bay of Fundy between Maine and New Brunswick, but so far construction of a dam even at this high-tidal-range location has been considered uneconomic. Another potential site is the estuary of the River Severn in Britain; but again, cost is the prohibiting factor.

In Brittany, France, a tidal plant was built across the River Rance in 1966. It consists of twenty-four 10-MW turbines that together can generate 240 MW in whichever direction the tide is flowing. However, operating and maintenance


Typical Energy Losses in Using Vegetation for Electricity Generation
100% of incident solar radiation
0% lost through leaf reflection and ineffective absorption
55% invisible light, unusable for photosynthesis
45% available for photosynthesis
31% lost in photosynthetic conversion
2% used for plant respiration and metabolism
3% delivered to power plant as fuel
2% lost in conversion to electricity
1% available as electricity

experience with the plant has not been encouraging; on average, the plant has operated for only about a quarter of the time, or 2000 hours a year.

Satellite power system

The orbiting satellite power system (SPS) is a concept designed to circumvent the problem of intermittent energy supply suffered by other solar setups; the satellite would be positioned far enough from earth to receive a nearly constant supply of sunlight, effectively avoiding the phenomenon of night. During the spring and autumn equinoxes—two periods a year of about 43 days each—the sun's rays would be blocked for about 75 minutes a day when the Earth's shadow fell on the SPS, but such interruptions would be quite brief in comparison with the normal terrestrial day-night cycle.

The SPS is generally envisaged as a very large photovoltaic electric power generator. Its components would be launched into geosynchronous orbit by a space vehicle whose gross lift-off weight would be about four times that of the Apollo Saturn V launch vehicle. The SPS would collect solar energy and convert it to electricity by an array of photovoltaic cells of approximately 50 km². This dc electricity would then be converted to microwaves and transmitted to a 30-acre (130-km²) receiving station on Earth. The microwaves would be reconverted to dc and then to ac electricity before being fed into a utility system.

The SPS concept has been evaluated by DOE and the National Aeronautics and Space Administration (NASA), who consider that an SPS might be constructed around 2000, with two satellites (and their ground stations) to be built each year for a period of 30 years.

However, there are several practical considerations that pose serious problems for SPS. For instance, environmental concerns surround the concept: long-term medical and biologic implications for humans, animals, and birds of beaming microwaves to earth; effects of ionospheric heating on local weather and regional climate; and radio frequency and electromagnetic interference to airplanes, radar, and other communications equipment from SPS microwave transmission. As yet, the effects are unknown.

The NASA plan involves 60 satellites, each of which would deliver approximately 5 GW of power at the utility interface. (For comparison of scale, a typical new fossil fuel generating station made up of 6 units may produce 1 GW.) Such large single units of capacity, positioned, as they would be, remote from Earth, would constitute an enormous reliability risk. In the event one unit fails, the capacity lost would be equivalent to the output of five conventional 1-GW generating stations.

In addition, the question of vulnerability of an SPS needs to be examined in the light of a threat to what might become a major component of the future U.S. electric power system. Also, international agreements would have to be obtained before any launching in order to allocate geostationary orbit space and microwave frequencies for the SPS.

NASA researchers estimate that each satellite and ground receiving antenna, plus associated equipment, would cost $10–$20 billion (1977 dollars), with the entire 60-satellite system costing from $600 billion to $1.2 trillion. This gigantic bill includes expenditures for developing the space transportation, training crews of 600 to assemble the SPS in space, and obtaining solar cell and satellite materials in the quantities required (which would consume much of the global supply of some materials at present levels of production).

In a report published in July 1981, the National Academy of Sciences stated that although solar power satellites might hold great potential for the twenty-first century, it would be premature to spend R&D funds on them in the 1980s. Further, much of the needed research for SPS will be conducted for other purposes. The report documents a review of the 3-year, $20 million DOE–NASA program by the Satellite Power Systems Committee of the National Research Council, the NAS operating arm.

The committee concluded that the program, which evaluated economic, social, political, and environmental aspects of SPS, was well conceived but extremely optimistic about costs. For instance, the committee found that the costs of crystalline silicon cells may be 10–50 times higher than the cost assumed in the program. Also, projected costs for transport to low Earth orbit were low by a factor of from 2 to 3. Moreover, the committee pointed out that aerospace projects are themselves suffering from cost overruns. Whereas the NASA program estimated an SPS to cost about $4000 per kW of installed capacity around 2000, the committee's best estimate stands at $10,000 per kW. This last figure is approximately 10 times the present average cost per kW of a conventional baseload electric power plant.

Many novel alternatives to fossil fuel combustion have been investigated in the overall R&D planning process. Those with the higher costs and risks have been given lowest priority and are, for the time being, losing federal support. Nevertheless, those concepts may be revived at some time in the future when, for reasons now unknown, they may appear more attractive. ■

Further reading

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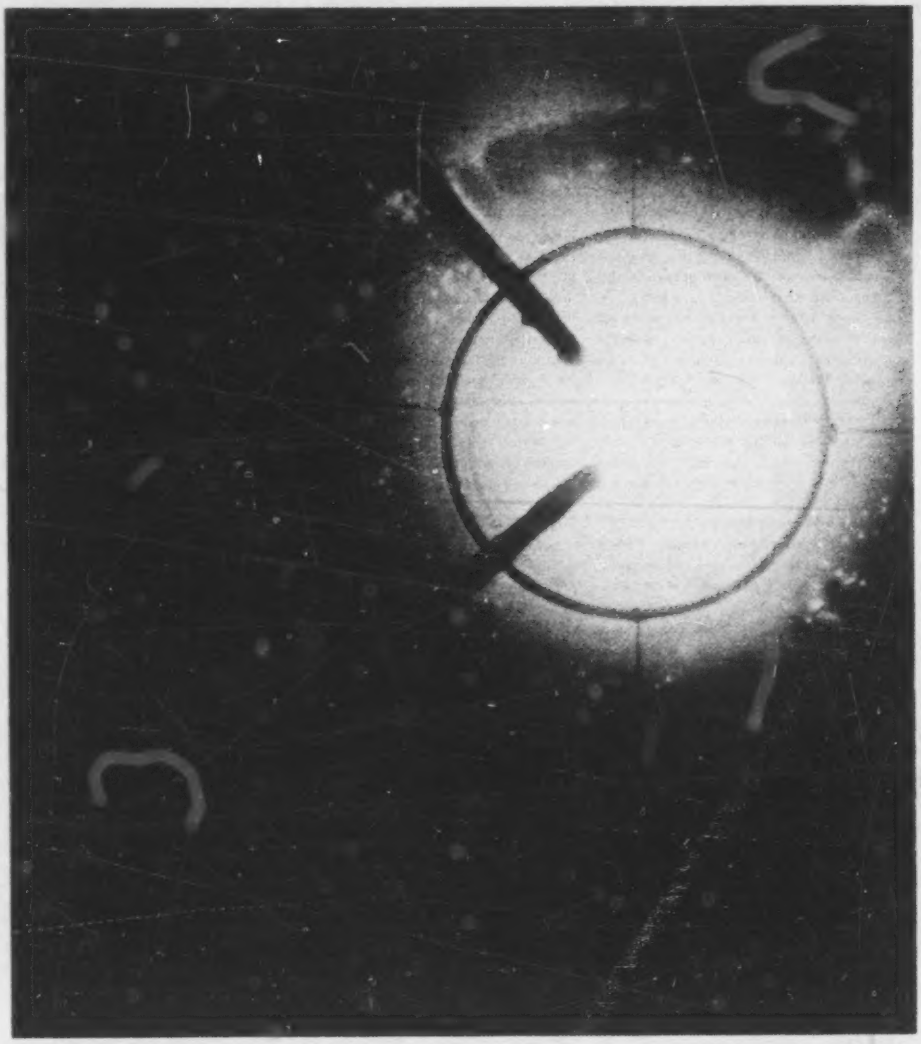
This article was written by Jenny Hopkinson, feature writer. Technical background information was provided by Edgar DeMeo, Advanced Power Systems Division.



Fusion: From Science to Engineering

With the vision of an unlimited and readily accessible fuel supply, several nations of the industrialized world have committed themselves to continued development of fusion technology. Research on scientific feasibility is well under way, and the shift to solving the immense engineering problems is now getting started. These problems are sufficiently complex to place the commercialization of actual power-producing fusion facilities at least 40 years in the future. A great number of questions about the nature, scale, and purpose of fusion reactors remain unanswered, clouding the direction future development efforts should take.

Fusion power research in the United States is moving from the phase of basic scientific research—that is, understanding the physics of fusion—to the phase of engineering development. This transition opens up a wide variety of potential pathways to an actual energy-producing plant.

Scientists and engineers are fairly confident that fusion energy break-even (as much energy produced as is required to set up the conditions for energy release) can be achieved within 5 years in fusion devices now being constructed. A U.S. reactor that will produce net energy (significantly more energy produced than is needed to operate the device) is probably an additional 10 years away, and a first commercial demonstration plant is perhaps 20 years in the future, although other nations—most notably, Japan—have expressed confidence that they will be able to reach this target earlier.

The long development time necessary to demonstrate a working fusion reactor is a measure of the extreme difficulty of the undertaking. A controlled fusion reaction requires that the gaseous fusion fuel be heated to incredibly high temperatures (100 million degrees Celsius) and that the plasma formed be suitably contained and kept away from the reactor's walls.

The formidable scientific and engineering obstacles that these requirements pose would probably remove controlled fusion from consideration as a promising future energy option were it not for the potential payoff. The promise, in brief, is that if fusion power systems could be developed, there would be a virtually unlimited supply of fuel available to run them. Earth's oceans are vast reservoirs of deuterium, the fusion fuel most likely to be used, at least initially. Deuterium can be extracted from ocean water by an uncomplicated and economical process, and the world's supply of fusion deuterium fuel would last well over a billion years at current world energy consumption rates.

The present transition from fusion science to fusion engineering means that basic decisions have to be made. Tradeoffs involving issues of technology, versatility, performance, and cost will affect these critical decisions, which, in turn, will determine the type and scale of fusion devices to be used in early commercial fusion plants. The engineering choices made in the near term will profoundly influence the course of fusion energy development for the next 20 years.

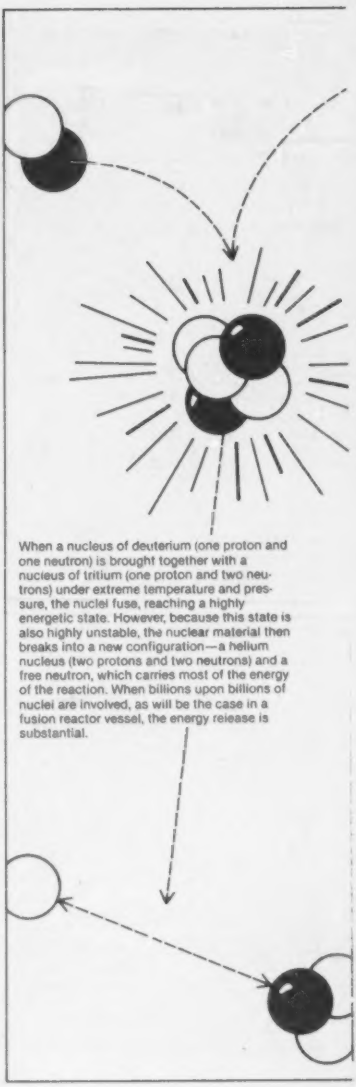
Magnetic confinement

To date, fusion energy programs in the United States, as well as those throughout the world, have emphasized research aimed at demonstrating an energy break-even device. Creating such a machine is not an easy achievement, regardless of whether the fusion device is based on the magnetic or the inertial confinement approach.

The leading contender in magnetic confinement is a doughnut-shaped (toroidal) configuration called a tokamak. An alternative type of magnetic device has a linear geometry. For example, the mirror machine is a straight tube surrounded by magnets along its length, with stronger magnetic fields at its ends; the plasma particles stream toward the ends, where the stronger fields reflect them back. Of all the variations of both toroidal and linear configurations, the closest approach to the conditions required for fusion burn has been achieved in tokamaks.

The biggest magnetic fusion device and the nation's first that will be capable of producing a significant quantity of fusion energy (although not electricity) is the tokamak fusion test reactor (TFTR) being built at the Princeton Plasma Physics Laboratory. Its startup is scheduled for August 1982.

Second in size to the TFTR is the mirror fusion test facility (MFTF), now under construction and scheduled for operation in 1985 at the Lawrence Livermore National Laboratory. This machine employs superconducting magnets of unprecedented size and is also designed to



When a nucleus of deuterium (one proton and one neutron) is brought together with a nucleus of tritium (one proton and two neutrons) under extreme temperature and pressure, the nuclei fuse, reaching a highly energetic state. However, because this state is also highly unstable, the nuclear material then breaks into a new configuration—a helium nucleus (two protons and two neutrons) and a free neutron, which carries most of the energy of the reaction. When billions upon billions of nuclei are involved, as will be the case in a fusion reactor vessel, the energy release is substantial.

FUSION BASICS

Nuclear fusion involves joining, or fusing, the nuclei of light chemical elements through the application of extreme temperatures and pressures. These conditions are necessary to speed up the motion of the nuclei enough to overcome the electrostatic repulsion that normally keeps them apart. When this happens and the nuclei fuse, nuclear particles are freed, and the extremely rapid motion of these particles represents a release of energy that can be recovered for practical use in the form of heat.

However, heating a gas to the temperatures required also has another effect—it causes electrons to be stripped from the nuclei. The resultant mixture of positively and negatively charged particles is called plasma. As the plasma is heated, it expands; unless it is contained, it becomes thinner and thinner until its low density makes substantial fusion energy release impossible.

The sun, which is a huge fusion reactor, accomplishes the reaction with relative ease. There is no plasma containment problem because the enormous mass of the sun holds the plasma by gravity to densities well in excess of those necessary for the fusion reaction. But there is no way to provide such a large gravitational field in a nuclear fusion device on Earth. Nor can a plasma density be achieved on Earth that would permit a fusion reaction at the relatively low temperature of the sun (15 million degrees Celsius); on Earth, the temperature must be higher—about 100 million degrees Celsius.

Heating the plasma can be accomplished by a number of means, including electric currents, radio-frequency waves, and neutral-beam heaters. Containment of the plasma is a much more formidable problem, however, because the plasma would immediately be cooled to subfusion temperatures by contact with any sort of physical container. There are two containment methods presently being pursued, differentiating fusion research into two areas: magnetic confinement fusion and inertial confinement fusion.

With magnetic confinement, large magnetic fields are used to control the plasma, which responds because it is made up of free charged particles. The magnetic field contains the plasma and keeps it from touching the walls of the physical container. Many configurations have been proposed for such a magnetic bottle, the most highly developed of which is the toroidal (doughnut-shaped) tokamak.

In inertial systems, brief but intense pulses of laser light or of atomic particles are used to irradiate a succession of fuel targets, or pellets (which can be as small as $\frac{1}{500}$ the size of a grain of rice), that contain fusion fuel. This irradiation compresses and heats the fuel to the density and temperature required for fusion ignition. The resultant rapid burning of the fuel yields a microexplosive energy release.

The fuel that will probably be used in early fusion devices is a mixture of two isotopes of hydrogen—deuterium (heavy hydrogen) and tritium (double-heavy hydrogen). Such a mixture makes up the plasma in magnetic devices and at high pressure is inside the pellets used with inertial devices. Deuterium is easily extracted from ordinary seawater; tritium occurs only rarely in nature, but can be bred from lithium by using well-understood nuclear processes. Such breeding will provide tritium to replace that which is burned in the fusion reaction, thus closing the fusion fuel cycle.

Tritium breeding is accomplished in the fusion blanket, which surrounds the reaction chamber. The blanket also serves the essential function in a fusion power plant of converting the nuclear energy released from the fusion reaction into thermal energy, which can then be used to generate electricity. The blanket can also be used to breed fuels for conventional fission power plants from relatively plentiful nonfissile material in what is known as a fusion-fission hybrid reactor.

Whether the fusion blanket is used to generate power or to produce fuel, its development is seen as a complex engineering challenge that is of prime importance to the future application of fusion technology. □

achieve the equivalent of break-even conditions (using hydrogen only).

A number of operational toroidal machines around the country are noteworthy because of the technological variations and innovations they are being used to investigate. For example, in 1978 the Princeton large torus (PLT) achieved plasma ion temperatures of about 65 million degrees Celsius, using neutral-beam injectors for heating, and in 1980 confirmed the scientific feasibility of using radio-frequency waves to heat plasma. The poloidal divertor experiment (PDX), also at Princeton, has essentially pure plasma at 11 million degrees Celsius.

The Oak Ridge National Laboratory has demonstrated steady-state operation of its first version of the Elmo bumpy torus—a toroidal configuration that differs from the tokamak in that the magnetic fields of the torus are not smooth. The capability for such continuous operation, not yet achieved by tokamaks, is particularly important for the development of commercial systems.

The Doublet, in operation at General Atomic Co. near San Diego, was designed to improve magnetic confinement while reducing the size of the magnets, which are among the most expensive components in magnetic fusion devices. General Atomic has also built and is testing another toroidal machine that it hopes will attain ignition of fusion fuel by ohmic (resistance) heating alone.

Magnetic confinement fusion, represented by these and other experimental devices, is technically more advanced at this stage than the other option, inertial confinement. The federal government has established the magnetic approach as its choice for fusion engineering development in passing the Magnetic Fusion Energy Engineering Act of 1980. This legislation established a goal to build and successfully operate a magnetic fusion demonstration facility before the end of this century. It further mandated that base programs for fusion energy research be maintained, including a strong R&D program in advanced fusion fuels, and that appropriate measures be implemented to ensure the availability of an uninterrupted supply of scientific and engineering talent in support of the magnetic fusion energy effort.

To pursue these ends, the act authorized the establishment of a magnetic fusion engineering center. The initial purpose of the center would be the definition, design, and construction of the next-step fusion machine—the fusion engineering device—by 1990. The act also stipulated that DOE define a structure for the fusion engineering center and draw up a comprehensive program management plan for the center's research. Because of embroilment regarding recent budget actions and program reevaluations, the fusion engineering center still remains undefined.

Inertial confinement

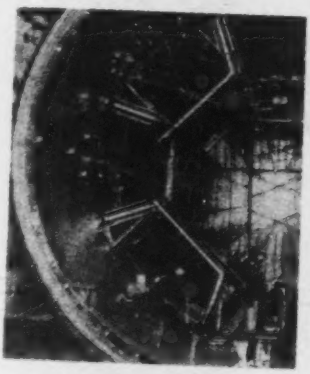
In the inertial confinement approach to fusion, a pulsed-energy source, called the driver, is used to compress and heat a succession of fuel targets injected into a reactor. Lasers were the first drivers used in such an application, but more recently particle-beam systems using beams of lightweight ions (e.g., hydrogen or carbon) or heavy ions (e.g., uranium) appear to have far better potential for achieving necessary driver requirements.

At this time there is no federal funding for commercially oriented inertial fusion research; only research for military applications is supported. Such research includes simulation of weapons effects and study of the physics of ultrahigh material densities. EPRI is continuing to study the commercial engineering development needs of inertial fusion. Fortunately, the DOE military applications program does provide funding for certain related research, such as driver development—a necessary element of any future commercial inertial system.

The laser inertial approach has been pursued through research on a number of large devices, including Shiva at the Lawrence Livermore National Laboratory, Helios at the Los Alamos National Labo-

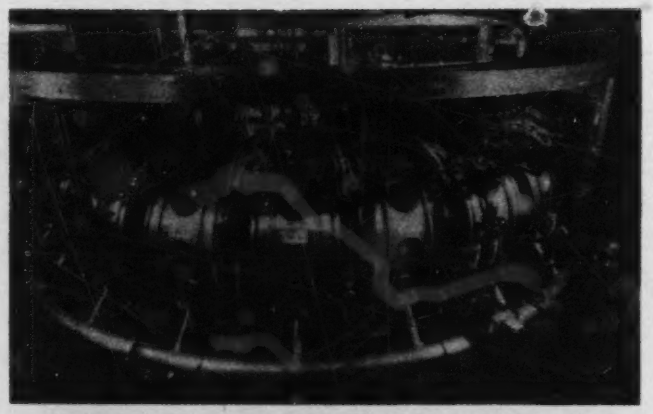
The Elmo bumpy torus, a steady-state magnetic confinement fusion device, uses electron rings to provide a stable environment for a toroidally confined fusion fuel. This system, operating at Oak Ridge National Laboratory, has provided the initial data for the design and construction of a much larger Elmo system under the direction of McDonnell Douglas Corp.

A vacuum chamber and magnetic field coils are key components of the mirror fusion test facility, which is under construction at Lawrence Livermore National Laboratory. When completed, the facility will test the validity of the tandem mirror concept for fusion confinement.



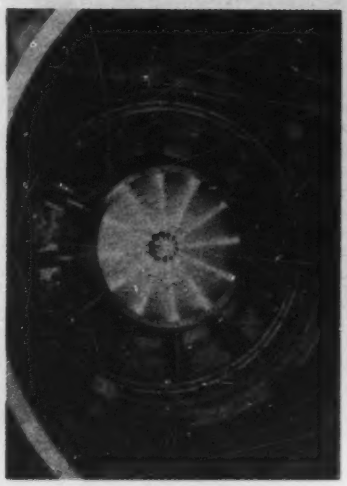
The particle-beam fusion accelerator at Sandia Laboratories is developing and demonstrating the light-ion inertial confinement approach to fusion. After the successful completion of pellet implosion and burn tests, expected by 1983, it will be upgraded to a device that will allow energy break-even tests. (right)

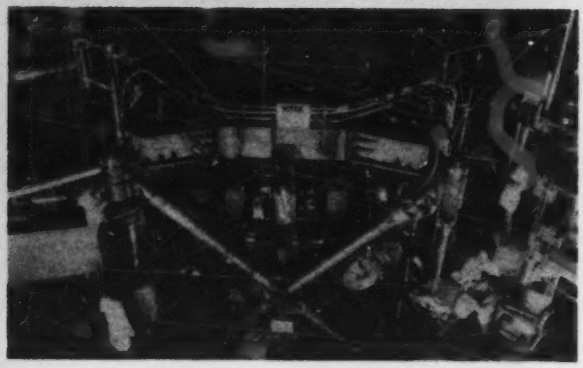
The poloidal divertor experiment at Princeton Plasma Physics Laboratory has demonstrated the ability of a magnetic divertor to purify and maintain a clean fuel in a stable tokamak system. (far right)



The large-tokamak facility at Princeton Plasma Physics Laboratory has used neutral-beam heating to produce fusion-reactor-like conditions of 65,000,000°C ion temperature and classical fuel confinement. Recently it also demonstrated sufficient heating with radio-frequency power. (center)

A scale model of the tokamak fusion test reactor shows the blanket module and test stand in place between the large toroidal magnetic field coils. This facility is under construction at the Princeton Plasma Physics Laboratory. When completed in 1982, it will be the first to test the ability of a system to make measurable fusion power.





ratory, and Omega at the University of Rochester. Because research has shown a need for even higher laser driver energies, larger systems are now under construction, notably Nova at Livermore and Antares at Los Alamos. Although the laser serves as an excellent tool for scientific development, the more recently introduced particle-beam drivers appear to offer significant advantages for ultimate use in commercial power production. These include better beam production efficiency (25–45%, as opposed to 8% for the laser) and higher coupling of the beam energy into the target. Additionally, the particle beams use lower-risk technology and overall appear to offer lower cost per unit of energy delivered to the target.

Sandia Laboratories has built and operated a light-ion (hydrogen ion) machine called PBFA–I, which will be used to conduct heating and fuel-pellet implosion experiments in 1982. The device has a circular array of 36 power modules that provide high-energy ions to be focused on a central target. When sufficient success at target compression and heating (the so-called significant burn) is attained, expected by 1983, the machine will be upgraded to PBFA–II, which will have more than three times the output of its predecessor. It is hoped that PBFA–II will attain break-even target burn during 1985.

Many believe that there are significant engineering advantages to the inertial confinement approach for producing commercial fusion power. Conceptual designs point to the possibility of a development path with smaller-scale facilities, conventional liquid-metal loops for energy extraction, and physical isolation of the driver from the radiation environment of the reactor vessel containing the fuel.

Whether such advantages materialize as the development of the inertial techniques approaches the level of magnetic fusion remains to be seen. EPRI is conducting a technical risk assessment for inertial confinement fusion that will examine the technical uncertainties and develop a research plan to deal with them. It is hoped that this project will help clarify the issue of the relative advantages of the two approaches.

Engineering challenges

The research programs of the last few decades that investigated the basic science of fusion have also yielded many results in engineering and technology development. There have been significant advances in such areas as magnets, plasma heating, lasers, high-vacuum systems, and various types of instrumentation. Through reactor design studies, many of the technology requirements for fusion plants have been defined, and as a result, specific important areas for future research have been identified.

Probably the area most crucial to the development of a commercial fusion facility is the reactor blanket system. This system is an essential part of a fusion plant because it provides the practical link between nuclear fusion reactions and usable output (energy or fuel). The engineering problems for this system are perhaps more complex than for any other fusion plant component, and blanket development is likely to be a costly and lengthy endeavor.

Although EPRI is conducting a number of projects on blanket systems, its main effort is the design and development of a blanket module to be tested for tritium breeding characteristics on Princeton's TFTR. It is anticipated that early fusion reactors will use tritium as one fuel component. Tritium will have to be bred to ensure a fuel supply. The test conditions will be less severe than those expected in a commercial-scale machine, but this research will nevertheless increase confidence in the blanket design and provide experience with large-size lithium-compound fabrication, operation of a module in a reactorlike environment, and module instrumentation.

A technology option that hinges directly on blanket research is the possibility of using fusion reactors to breed fuel for fission reactors. The breeding process would be accomplished in much the same way as for tritium except that plentiful, nonfissionable heavy elements, such as uranium-238, would be loaded into the blanket in addition to the heat transfer medium. Such fusion-fission hybrid reactors could be designed either as dual-purpose machines (that is, to generate electricity as well as to breed fission fuel) or to breed fuel exclusively.

EPRI is currently evaluating whether work on such a fusion-fission hybrid should be a major effort in its fusion program. Certain scenarios for future energy supply and demand indicate that there could be shortages of fission fuels early in the next century. If this should prove to be the case, the continuation of the fission energy industry will depend on finding new sources of fuel. It has been estimated that one fusion-fission hybrid of less than 1-GW (e) output could supply the annual fission fuel needs of 10 or more conventional 1-GW (e) fission power plants. Of course, the worth of developing the fusion-fission hybrid is predicated on the reestablishment of a robust fission-based nuclear power industry, a reversal of the current trend.

The utility role

Although fusion remains high on the DOE priority list and its budget remains relatively intact, support from the electric utility industry is considered of growing importance as engineering development proceeds. The Magnetic Fusion Energy Engineering Act includes the expressed intention that the fusion engineering center be an industrial organization operated in an industrial fashion; nevertheless, the specific balance of government, industry, and utility involvement has not yet been established.

Because the utilities are almost certain to represent the major market for any fusion devices that are developed, a full understanding of their unique operating environment will be essential in designing an attractive machine. If the research produces a machine that does

FUSION RESEARCH IN OTHER COUNTRIES

Several countries besides the United States, including the Federal Republic of Germany, France, Great Britain, Japan, Italy, and the USSR, are pursuing ambitious programs of fusion research in efforts to develop commercially useful fusion reactors.

A group of western European nations is working jointly on fusion through the European Atomic Energy Community (Euratom). Euratom has just received a recommendation from a scientific review committee (composed of scientists from universities and from the aerospace, electrical, and nuclear power industries) that funding for fusion R&D be increased 30% over the next five years.

In addition to the funding increase, the committee recommended that the joint European torus (JET), a tokamak about the size of Princeton's TFTR, be pushed ahead as fast as possible and completed in 1982. JET is now under construction at Culham, England. The scientific review committee also recommended that Euratom "initiate a substantial and well-balanced program in fusion technology, mainly focused on the solution of the technological problems of NET (next European torus)."

Another joint international project, involving the United States, USSR, and Japan, is the international tokamak reactor (Intor), under the aegis of the International Atomic Energy Agency.

In addition to constructing a large tokamak with superconducting magnets, the Soviets plan to build a tokamak that they say will achieve a continuous fusion reaction by the late 1980s. Stephen Dean, president of Fusion Power Associates, a trade organization, cautions that "these two Soviet devices, taken together, will demonstrate the engineering practicality of fusion before 1990, well ahead of the current U.S. timetable." It is notable that the USSR has as a research goal the development of a fusion-fission hybrid—that is, a fusion plant that will produce fuel for use in fission power plants.

The magnitude of Japan's commitment to fusion energy is such that some Western observers think the Japanese will be the first to demonstrate a fusion power plant. Japan's JT-60 tokamak, about the size and power of the TFTR, is scheduled to begin operation in 1984.

In addition to the Japan Atomic Energy Research Institute, builder of the JT-60, Japanese universities and industry are heavily involved in fusion research, including laser research at Osaka University, studies of heliotrons at Kyoto University, work on a stellarator and bumpy torus at Nagoya University, and research on magnetic mirror machines at the University of Tsukuba.

In March of this year, Japanese scientists recommended a fusion energy development plan that is the world's most ambitious: it calls for Japan to have a 400–800-MW (e) demonstration fusion reactor on-line, generating electricity by 1993. Thus the Japanese plan to skip the intermediate engineering facility that has usually been considered a necessary development step and go immediately to an experimental power reactor. □

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not respond to the utilities' needs—a fusion white elephant—it is not likely to be bought and used. The utilities need a reliable device that meshes readily with existing operation and maintenance capabilities.

Identification of such utility needs and evaluation of the potential of various types of fusion devices to meet them has been a major objective of the EPRI fusion program. Using technical risk assessments, the program is now identifying the technical uncertainties associated with engineering designs of systems that may be desirable for utility end use. With this information, the requisite research and technology development plans can be formulated.

The crucial question that must be answered is what is the best development path to follow. The answer is not yet clear, but it will ultimately emerge from other fundamental questions now being explored. For example, what should the ultimate goal of fusion be? Utilities may prefer that it not produce power, but rather that it be a source of fissile fuel that can be used in a stable of well-understood, in-place fission reactors. Should the development path be one of lower physics risk—advancing the plasma confinement concept that now appears to be closest to achieving breakeven? What if this "low-risk" option proves to be unsuitable for utility system integration? Should all activities be focused on magnetic fusion, or should a parallel activity be mounted in inertial fusion? Should, in fact, several configurations for each of these continue to be nurtured to promote flexibility in ultimate applications? If this is done, what criteria should be used to narrow the field during the development effort?

Confronting such a complex of choices makes it apparent that careful planning is necessary to ensure a well-balanced, supportable, and eventually productive development plan. Commitment to a single approach at this time may be premature. It should be apparent that fusion still has a long way to go before demonstrating engineering feasibility and even further for economic credibility. Those supporting fusion R&D must be fully aware of this and convinced of the importance of protecting the support of such long-range research.

Involvement of the utilities is clearly desirable at these decision crossroads to establish what it is they want from fusion and, just as important, what it is they do not want. Such user viewpoints are critical to a comprehensive program management plan, the fusion engineering center, and the fusion engineering device. It would appear that the fusion community and the utilities now have a unique opportunity for jointly directing the development of a new energy source of far-reaching potential. ■

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This article was written by John Kenton, communications specialist. Technical background information was provided by Kenneth Billman, Advanced Power Systems Division.

Policy Impact

What future lies ahead for renewable resources in light of reduced federal support? Some experienced Washington observers offer their opinions.

Renewables—solar, geothermal, hydro, and fusion—received strong emphasis during the Carter administration, and support for research, development, and demonstration projects accelerated at a rapid pace. The Solar Energy Research Institute was established in Golden, Colorado, and the president even brought renewables into the White House with the installation of a solar hot water heating system.

But the climate surrounding renewables changed with the inauguration of a new administration dedicated to trimming the federal budget and reducing inflation. Whereas the Carter budget for direct R&D support for solar, geothermal, and fusion rose to nearly $1.5 billion, the Reagan administration has requested deep cuts in the solar and geothermal R&D budgets. Only the fusion budget will survive essentially intact.

Also discussed within Washington energy circles is the possibility that the administration will attempt to eliminate some of the indirect support, notably the tax credits currently available to homeowners, businesses, and industries for the installation of solar and other alternative energy equipment.

What implications do these actions—taken or postulated—hold for the future of renewable resources? The *EPRI Journal* recently talked to several individuals within the Washington, D.C., energy community who have observed or participated in federal activities in renewables over the past several years and who have some tie with or knowledge of private industry. Although this group of observers can by no means be considered a scientific sampling, their opinions can help shed light on the current status of renewable resources in this period of uncertainty.

As might be expected, there was no one perspective shared by all individuals. Opinions ranged from guardedly optimistic to generally pessimistic to a feeling that the federal role will not make much of a difference.

"I think it's reached a point it would have anyway," said Llewellyn King, publisher of *Energy Daily*. "And that's the business of when do you stop pampering a technology and let the market take over. I think you will see a low level of growth as a genuine market develops as opposed to an artificially stimulated one. I think that alternative energy is here, although it's not here on the grand scale that some envisioned, and it never will be."

"With the exception of wood-based biomass systems, I am pessimistic about the ability of the renewable energy industries to survive, let alone contribute significantly," stated Bennett Miller, vice president for energy programs of Fred C. Hart Associates, Inc. Miller served as DOE's deputy assistant secretary for solar energy during 1980–1981. "In general, the renewable energy industry is an infant industry and has depended on federal R&D activities for much of its support over the past few years. Although there are some major firms involved, in many cases it is still a cottage industry. As such, when there is a dramatic cutback in federal support, it is going to impact the growth of that industry severely."

"I don't think that the federal role [in renewables] is really crucial," said Larry Hobart, assistant executive director of the American Public Power Association. "The important thing is, are these technologies economic in terms of additions to the energy supply? It wasn't federal funding that stimulated the interest of public power systems in renewables in the first place. It was the possibility that there might be available now, or in the short term, economic sources of energy from renewables."

Because renewables encompass many different technologies at very different stages of development, it makes sense to

examine them individually. "You can't give a bottom line answer and say it's applicable to all renewable resources," stated Thomas Melloy, group director for renewable resources of the General Accounting Office's (GAO) Energy and Minerals Division. Wilson Prichett, alternative energy specialist at the National Rural Electric Cooperative Association (NRECA), agreed. "Some technologies are going to make it and some aren't."

On certain technologies—those at the extreme ends of the time spectrum—there was general agreement among the observers about future prospects. Almost everyone, for example, felt that neither fusion nor such advanced solar concepts as ocean-thermal energy conversion or the solar power satellite would survive without federal assistance. On the near-term end of the spectrum, there was general agreement that utilities and entrepreneurs are sufficiently interested in small hydro, passive solar, and (to some extent) biomass to develop the potential of these technologies without federal support. Regarding other renewable technologies, such as active solar heating and cooling, wind, photovoltaics, and geothermal, disagreement was more widespread.

Hydro and Biomass

Beginning at the near-term end of the spectrum, hydroelectric power, particularly low-head hydro, was one technology that most observers seemed to agree would be least affected by cutbacks in federal funding. "Hydro is the one source that most rural electric cooperative utilities are interested in," stated Lowell Endahl, NRECA's manager of energy research. "This is evidenced by the number of coops that have applied for permits."

"It's the resource with the most sex appeal of all," agreed Hobart of APPA. "It's an old approach to power production. Everyone knows how to deal with it. It's off-the-shelf technology. It can be operated remotely. You can buy turbine generators of almost any size, and projects may last for 100 years." Hobart explained that municipals have a particular interest in hydro because many of the sites are located in or close to cities. He expects that interest to continue, regardless of the federal role.

A similar feeling was expressed by Glenn Lovin, alternate energy applications manager at the Edison Electric Institute. "I think investor-owned utilities will pursue and develop hydro power and I think we will pursue and develop it without federal involvement."

There was some concern expressed, however, about the negative effect on hydro that might occur if changes were made in the current favorable tax and regulatory framework. By provision of the Public Utility Regulatory Policies Act (PURPA) of 1978, utilities are required to buy power at their avoided costs from small power generators. "In certain parts

of New England and the Middle Atlantic states, low-head hydro has a lot of promise made possible by PURPA," commented Kennedy Maize, formerly a reporter for *Energy Daily* and now with the Environment and Energy Study Conference of the Congress. "If PURPA were changed to eliminate the necessity of a utility paying essentially premium price for that power, it would hurt. Some small hydro would not come on."

Terry Johnson, legislative director of Solar Lobby, a citizen's interest group, also brought up the possibility that the tax advantages currently enjoyed by hydro may be on the same chopping block as other tax credits for solar. The law currently allows a 21% tax credit for private investors building small-scale hydro plants. Tampering with this tax advantage would hurt hydro, Johnson maintained, although he conceded that this technology is a little less sensitive than others to federal involvement.

Some observers also felt that conventional forms of biomass would be pushed by economics (in regions with sufficient quantities to fire small boilers) and therefore might be less affected than other technologies by federal funding cutbacks. "Wood-based biomass systems are near-term winners and don't need much federal help," stated Miller. "That's not to say that federal help wouldn't move them along more rapidly, but I think the state of the technology is such that industry can handle the required investment in development costs."

GAO has also examined federal work in municipal solid waste and, in a recent report, concluded that reduced federal funding for utility-related R&D projects would not cause any significant delays in the acceptance and use of this technology. Funding in this area, according to GAO, has been relatively small.

In other areas of biomass, the federal role appears more crucial. Johnson, of the Solar Lobby, expressed belief that reducing tax advantages for biomass would hurt the potential of alcohol fuel production. "It would be devastating," he declared.

Passive and Active Heating

Another renewable technology that most observers seemed to feel would remain viable despite federal funding cutbacks is passive solar, which incorporates energy-efficient design principles into buildings.

"Passive solar is totally here and probably never needed any federal help," stated Paul Maycock, formerly head of DOE's photovoltaic program and now serving the dual role of president of Photovoltaic Energy Systems, Inc., and senior associate of the Renewable Energy Institute.

King of *Energy Daily* was especially optimistic about the future of this concept. "These are really conservation

devices much more than they are raw sources of energy," he noted. "They're assists. And the concept of solar-assisted conservation is now fundamentally ingrained. It has become institutionalized in our way of thinking. It's very akin to concern with the environment. And even if the environmental movement went away—which it's not going to do—we would still have that concern. Likewise, if all government support of renewables went away—tax credits, budget cuts, the lot—we would still have an industry out there. The job has been done. It's quite extraordinary."

Even though most observers were optimistic about the future of passive solar, some reservations were expressed about the depressed state of the economy in general and the housing industry in particular and about the limited possibilities for passive solar in retrofitting the existing housing stock.

Regarding active solar heating and cooling systems (SHAC), which can be roughly divided into hot water heating systems and space heating and cooling systems, there was a bit less uniformity of opinion among those interviewed. Some individuals were optimistic about the status of solar hot water systems, despite federal funding cutbacks. "It's probably the most solidly established technology," stated Alan Howe, director of government relations of the Solar Energy Industries Association (SEIA). "There really isn't a great deal of effort going on in DOE now in this area. Basically, I would think the budget cutbacks would have very little impact in that area."

"There's already a market for solar hot water," stated GAO's Melloy. "You can go to Sears and buy one of its systems in certain regions of the country."

But Miller of Hart Associates cautioned that domestic hot water systems will continue to be expensive and unless the economy improves, the firms involved will not be able to do the R&D necessary to push the cost down. "There will be a slowing down," he said.

Turning to active solar systems for space heating, many of the opinions were less optimistic. GAO's Melloy, referring to DOE's SHAC demonstration program, which included thousands of units in the commercial, residential, and military sectors, said, "Our reports showed that many of the systems were faulty. Where we had good data, the data showed that most systems were not economical. We saw one space heating system with a payback period of over 999 years. What would cutting off federal support for R&D and financial incentives mean? If these were typical solar projects and federal support were cut off at this stage, it could be the death knell to solar space heating and cooling, at least."

Melloy is not confident that private industry will pick up work in this area. "I think we're in a sufficiently uncertain period of time that we just don't know for sure. I think what is crucial is that what has been done with these technologies to get them to the point where they are now shouldn't be discarded without having some degree of assurance that the good ones will be picked up. A lot of taxpayer dollars have been invested in developing these technologies and promoting their use."

Most observers seemed to feel that the most detrimental action the federal government could take regarding SHAC would be to eliminate the tax credits currently available for installation of solar equipment. "It would totally gut the market," Miller said. "The fact is, the tax credits are a psychological boost."

Lovin of EEI, however, expressed belief that even with elimination of the tax credits, a market would still exist for solar in the home, although it would be a limited one. "We will continue to have rising electricity costs, and therefore the consumer will continue to look for ways to offset the electric bill. The market is there and will continue to be developed, but we just don't see a major spread of these applications in this country because of the expense and initial cost of installing the systems."

If the administration does propose elimination of the tax credits, will Congress acquiesce? Many felt that it would not. "There is a recognition on the part of the administration that the solar and conservation tax credits are quite popular and they would have a rather difficult time in Congress repealing them," stated Howe of SEIA. In fact, more than 260 members of the House and 60 members of the Senate have signed resolutions opposing repeal of the tax credits.

Wind and Geothermal

Wind is another technology for which advocates argue financial incentives are necessary. "If the tax credits were repealed, it would present a serious problem," stated Thomas Gray, executive director of the American Wind Energy Association. The tax credits for wind are 40% of the first $10,000 for residential users and 15% (in addition to the standard investment tax credit of 10%) for businesses. "The economics of the wind farm projects depends heavily on the tax credits and the stability of the investment climate."

Maycock believes wind has an excellent chance of surviving, given the current tax structure and PURPA, which allows producers to sell electricity to a utility at favorable rates. But he said that if these two incentives were eliminated, "we would have a very difficult time."

Several of the observers also mentioned reliability as a major factor in determining the future of wind systems. "It's going to be the ultimate determinant of who gets along and who doesn't," said

Gray of American Wind Energy. "Within the small wind field, you can already see that the companies producing hardware that stays up are moving ahead much more swiftly than those that don't."

Assessing the reliability of large wind machines (100 kW and up) as a group is difficult, Gray maintained, because there are so few in existence in the United States. He does not believe that the problem of reliability will be as severe with the larger machines because of the substantial financial investment that will be required. "The companies that are producing large machines will be very sure to do whatever they can to make certain their machines are reliable."

A number of those interviewed expressed belief that wind would survive federal cutbacks, but on a small-scale, local basis. "It may go in some areas, but it's not likely to sweep the country," noted Hobart of APPA.

"Large-scale wind machines are a very dubious proposition," stated King of *Energy Daily*. "Industry won't pick them up. I do think you will see industry marketing windmills for site-specific small-scale use—out on a prairie or in coastal regions or in some rural situations where their cosmetic impact is modified by space."

Geothermal energy is also a technology that many observers felt would survive without federal assistance, but would be local in nature and perhaps limited in its development. "Where it exists, utilities are interested in a geothermal resource," stated Hobart of APPA. "Our members in northern California are going ahead with geothermal development totaling a possible 350 MW. I don't sense that the federal expenditures are crucial. Access to economic resources coupled with the ability to transmit the resultant power are the key things."

"I don't think reduction of federal support will have as much impact on geothermal as on some of the other technologies," said Lovin of EEI, "because where you can identify geothermal resources, I think the utilities would consider moving ahead."

Melloy from GAO believes that some geothermal applications would go without federal support, but development of its full potential would not take place. GAO has been active in reviewing federal work in the geothermal area. One recent report examined the effect that eliminating funds for a particular project would have on geothermal development. In its report, GAO concluded that elimination of federal funds for the binary-cycle geothermal demonstration project near Heber, California (which is also supported by EPRI, San Diego Gas and Electric Co., the Imperial Valley Irrigation District, California Department of Water Resources, Southern California Edison Co., and the state of California), would impede the full development and widespread use of hydrothermal resources. Realizing the full potential of hydrothermal resources depends on development of the binary cycle, the report states. The utility industry has indicated that it needs a commercial-scale plant, such as Heber, to resolve economic uncertainties and technical risks that currently exist with binary-cycle plants. Without federal funding, it appears that Heber will be terminated, the report states, an action that would delay commercialization of binary-cycle technology and widespread use of hydrothermal resources. This is one example, Melloy pointed out, of a technology that would not go forward at this time without federal funds.

Solar-Thermal Electric

A similar belief was expressed about the future of the power tower, a solar-thermal technology. "I'm a firm believer that the project at Barstow, California, will not only work but will show the way," stated Miller of Hart Associates. "However, I think solar-thermal for large-scale, central power generation will be hard to come by without some up-front help from the federal government, at least in getting the manufacturing started."

"Solar-thermal has almost totally been financed through government R&D," stated Howe of SEIA. "Some major companies in the aerospace industry have invested a lot of money, and they are hoping the government will continue its partnership with them. If it does not, I really can't see how these companies could sustain the costs. The market is really with the utilities in these higher-cost, higher-temperature central receiver technologies. Unless the utilities invest and become partners with developing companies in this technology, I don't know that we will have the capital to do it."

"The power tower offers some potential, and if the federal government continues its support, it would offer some assistance in certain parts of the country for replacing imported oil," stated Lovin of EEI. "As it stands now, based on the other financial requirements of utility companies, I don't see any movement in this area, except to the extent that certain companies in certain parts of the country will look at it for certain applications in retrofitting old plants."

A recent GAO report analyzing federal funding for electric utility R&D projects identified solar-thermal energy conversion as one of the technologies for which demonstration projects would not go forward if proposed budget cuts are implemented. "The electric utility industry has R&D efforts in these areas, but because of financial problems, risks associated with demonstration, and the large investments required, it will not carry out demonstrations on its own," the report stated. "Without such demonstrations, it is likely commercialization will be delayed or perhaps not occur."

Photovoltaics

Discussion of the federal role in photovoltaics brought several different opinions. Maycock, who guided DOE's photovoltaic program until last March, was very optimistic and expressed belief that a reduced federal program would not delay the technology's reaching economic viability for more than a few years. "Photovoltaics will survive because it has investor appeal," he maintained. "And I think the momentum toward attaining economic viability in the mid-1980s is still there. We now have a rather large array of options dedicated to cost reductions in materials. We really need only one of these options to come through. Not only do we have a strong technology base but we also have a large amount of risk capital coming in, primarily from the oil companies. And it is coming from those companies that generally didn't have support from DOE. So I think there is a very good chance that we will see a healthy industry."

Maycock cautioned, however, that it is very critical that the next step in cost reduction for photovoltaic cells occurs. He said that this is the price that allows photovoltaics to compete with diesel fuel in a small diesel generator. This is important because it opens up "an awesome market" in remote parts of the world where water is pumped or electricity is made with diesel or gasoline generators. Most analysts put that price between $4 and $6 a peak watt installed, whereas the price of a module alone is now $9–$11 a peak watt, with a system's installed cost at three times that price.

"If $4 a peak watt is not met by 1984, it is going to be very difficult to get to the next step—$2 a peak watt—which makes photovoltaics a reality for the United States," he declared. But Maycock believes that industry will be able to meet this target, even without federal assistance. "I've had a chance to talk with industry, and I think we can pull it through."

There was concern expressed, however, that some small photovoltaic companies that depend on DOE funds would probably go under if they are not acquired. "If your perspective is a diversified industry, you may not have one," said George Tenet, director of photovoltaic and international programs for SEIA. "You will have large company participation, but there will not be many small companies left, and that may mean that some markets will not be addressed." Johnson of Solar Lobby agreed and noted that these smaller companies are often the ones that have provided much of the innovation in the industry.

The solar people also expressed deep concern about the effect that reduced federal funding would have on the photovoltaic industry's ability to compete in foreign markets. "Most of the photovoltaic market is now in the international arena," noted Howe of SEIA. "And most of it is in the developing countries that have no real central service system of electricity. We have severe competition there from the Japanese and the French industries, which are heavily subsidized by their governments. In fact, the Japanese government thinks this is an area in which it can capture dominance in the world market.

"The government needs to stay in the photovoltaics area," Howe continued. "We do need some assistance in perfecting different types of materials, as well as some assistance in the international marketing area, simply because we are being pressed very strongly by competition from countries that are heavily subsidizing their industries."

SEIA's Tenet pointed to another way in which reduced government support hurts the photovoltaics industry both at home and abroad. "The perception in world markets that your government values your technology and is willing to spend money on it means something to a foreign buyer. The perception that your technology may not be as good because your government is getting out of supporting it is something that will be difficult to deal with in the foreign market. The Third World really values what the government is doing with your industry."

Tenet also believes that the price goals DOE established for photovoltaics have hurt the ability of the United States to compete in foreign markets. "The price goals are unrealistic in the first place because they don't reflect all the costs associated with getting a product to the market, such as transportation, marketing, and systems costs," he stated. "And because of the faith that these foreign buyers have in government statements, they put off buying now because they think the cost may come down in a few years. The valid basis of purchase should be how the price of photovoltaics compares with other fuels."

Federal Support

Can any general conclusions be drawn from this diversity of opinions? Although no one answer applied to all technologies or was agreed to by all observers, it seems fair to say that the majority felt most renewables would survive federal funding cutbacks. Certain ones would not. Others would be slowed down and only achieve small-scale, local application. But enough would make it to keep renewables alive in the country. If the tax credits are eliminated, however, or such regulatory measures as PURPA are amended, the pictures will become considerably gloomier. Most agreed that these actions would be the ones to severely hurt the future of renewables in this country. ■

This article was written by Marie Newman, Washington Office.

TECHNECON

TECHNECON ANALYTIC RESEARCH, INC. • 2400 CHESTNUT STREET • PHILADELPHIA, PA 19103 • (215) 561-5462

March 26, 1982

The Honorable Don Fuqua
Chairman
House and Science Technology Committee
2321 Rayburn House Office Building
Washington, DC 20515

Dear Congressman Fuqua:

Knowing of your interest in non-nuclear energy programs and of your Committee's concern for energy program funding, I am enclosing for your information a paper recently prepared by my firm which addresses the national outlook for geothermal power development. The paper was presented last month at the 9th Energy Technology Conference in Washington and discusses the results of 4 years of intensive research. This material may be of value to your Committee's current considerations of Federal funding for geothermal energy programs.

For the past decade my colleagues and I have worked with the geothermal industry, providing consulting services on various projects for the government, major corporations and private investors. From this experience it is apparent that the industry suffers from both: (i) a resource base that is fragmented among hundreds of leaseholders -- only a small fraction of which may be classified as "active" developers; and (ii) except for a handful of oil companies, the majority of geothermal leaseholders are poorly capitalized and incapable of funding comprehensive R&D activities. While we can point to a half-dozen small demonstration plants now in progress, long-term and potentially high-payoff R&D programs in the geosciences, advanced energy conversion, drilling technology and well pumps are unlikely to be undertaken by private industry.

We agree with the President's Sunset Review and with the November report of the Energy Research Advisory Board (ERAB) insofar as they contend that industry is "capable" of solving geothermal problems. Indeed the argument may be made that -- given time, motivation and resources -- private industry is "capable" of solving any technological problem that the government might otherwise solve. The issue here, with respect to needed geothermal R&D, is not one of private industry "capability" but rather one of private industry "willingness". In this respect we agree with the General Accounting Office warning that the administration has overstated the willingness of private industry to undertake needed R&D activities.

My firm has no vested interests in geothermal resources other than those of every citizen concerned with domestic energy development and security. We believe, nonetheless, that Federal funding of geothermal programs is important, particularly in light of the promising high payoff from these programs (see attached graphic). In this regard, we wholeheartedly support your proposed $150 million increase to Solar and Geothermal programs for the FY 1983 budget, as reported in today's issue of "Inside Energy".

Please feel free to call me if you have any questions or comments about this material.

Very truly yours,

TECHNECON ANALYTIC RESEARCH, INC.

Thomas A.V. Cassel, Ph.D., P.E.
President

gp

Enclosure

HIGH NATIONAL PAYOFF

	GEOTHERMAL POWER BY 2000	CRUDE OIL ENERGY EQUIVALENT
Without Gov't Program:	4,300-7,200 MWe	150,000-250,000 Bbl/Day
Continued Program:	12,700-17,400 MWe	450,000-600,000 Bbl/Day

TECHNECON

NATIONAL OUTLOOK FOR GEOTHERMAL ELECTRIC POWER DEVELOPMENT

Thomas A.V. Cassel, Ph.D., P.E.
Technecon
Philadelphia, PA

The promise of geothermal electric power is realized in the United States today largely due to the pioneering efforts of B.C. McCabe and his partners in Magma Power Company. In the mid-1950's, Magma drilled the first commercial steam well at The Geysers area in northern California. Subsequent joint development by Magma, Thermal Power Company and Pacific Gas & Electric Company provided the western hemisphere's first commercial geothermal electric power (11 MWe) in 1960. Seven years later Union Oil Company of California joined the developers and, with its ample supply of investment capital, substantially accelerated the growth of generating capacity at The Geysers (see Figure 1). Today, with more than 900 MWe of installed capacity, natural steam from The Geysers supports the world's largest geothermal electric power complex. Geothermal energy reliably supplies an appreciable fraction of the electricity demand in northern California at costs which are substantially lower than those of any fossil-fired or nuclear alternative.

The Geyser's success, coupled with today's strategic concern for domestic energy production, have contributed to a timely national interest in geothermal resource development. By 1985, the geothermal industry has announced commitments to have more than 1,900 MWe of generating capacity in service -- more than double the development of the last twenty years. Whereas practically all of the commercial geothermal power in the United States to date has been produced from The Geysers vapor-dominated resource, the next 4 years will witness the first substantial development of generating capacity outside of The Geysers. As indicated in Table 1 (ref. telephone survey of developers and utilities, January 1982), roughly 25% of the planned geothermal additions between now and 1985 will be from technologically challenging, liquid-dominated resources in southern California, Utah and Nevada.

Presented at the 9th Energy Technology Conference, Washington DC, February 18, 1982 and published in Energy Technology IX - Energy Efficiency in the Eighties, Government Institutes Inc., Rockville MD, July 1982.

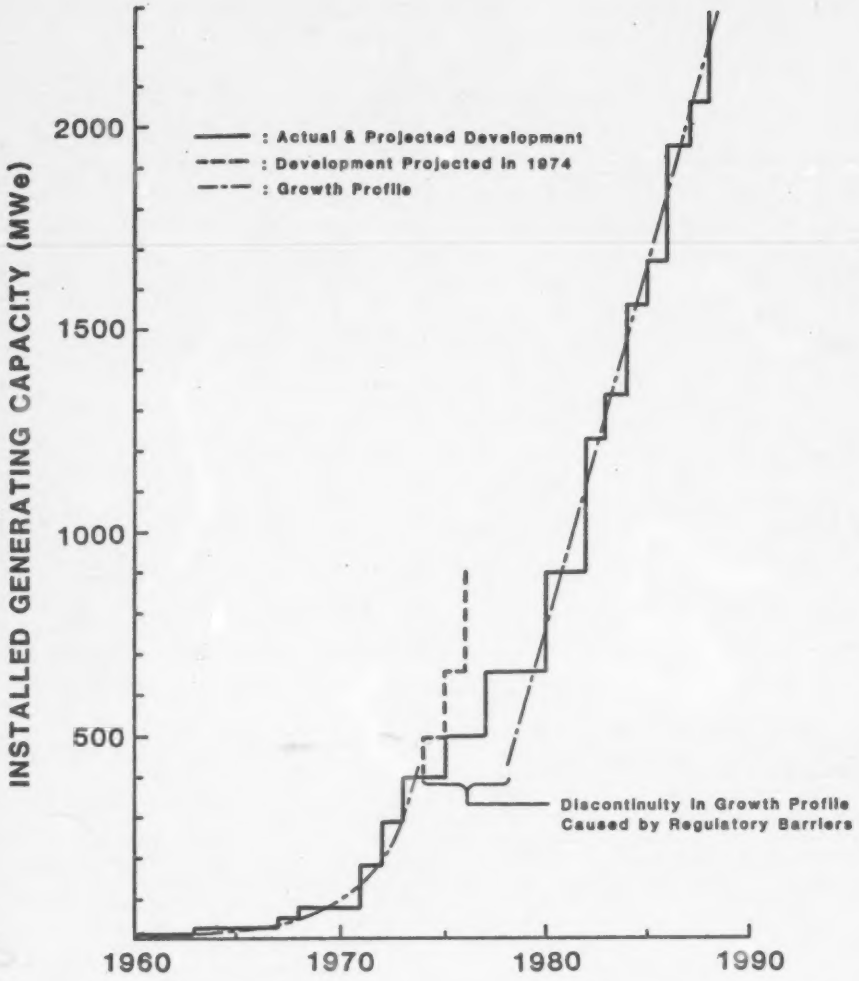

Figure 1. GEOTHERMAL POWER DEVELOPMENT AT THE GEYSERS VAPOR-DOMINATED RESOURCE, NORTHERN CALIFORNIA

TABLE 1. GEOTHERMAL ELECTRIC POWER PROJECTION FOR 1985 [MWe (net)]

	Currently in Service	Planning Commitments (1982-1985)	Speculative Additions (1982-1985)	Possible Total by 1985
Vapor-Dominated Resource: The Geysers (CA)	902	785	66	1,753
Liquid-Dominated Resources:				
Baca (NM)			45	45
Beowawe (NV)		10		10
Brawley (CA)	10	45		55
Coso (CA)			20	20
East Mesa (CA)		21		21
Heber (CA)		92		92
Mono-Long Valley (CA)		7		7
Niland (CA)		38	25	63
Puna (HA)	3			3
Raft River (ID)		5		5
Roosevelt (UT)	2	20		22
Westmoreland (CA)			48	48
SUBTOTAL:	15	238	138	391
TOTAL PROJECTION FOR 1985:	917	1,023	204	2,144

Although economic electric power generation has been clearly proven at The Geysers, this vapor-dominated type of resource is rare and may be the only one of its kind that can be exploited in the United States. Liquid-dominated resources, on the other hand, occur relatively frequently in nature but, in may cases, carry a substantial degree of investment risk. Among the technical problems faced by developers at many of these resources are materials corrosion, scale formation, effluent disposal, fluid reinjection, pressure and temperature drawdown, land surface subsidence, induced seismicity, and the lack of effective geothermal well pumps and low-temperature (<350F) energy conversion technology. The severity of these problems and the economics of production depend upon resource qualities including local lithology, hydrology, fluid composition, temperature, depth, porosity and permeability. These qualities of liquid-dominated resources vary significantly from one area to the next such that resources which are geographically close may be geologically and geochemically very dissimilar. To date, Federally-funded research, development & demonstration activities and loan guarantee programs have been successful in ameliorating site-specific technical problems and perceived investment risk at a number of liquid-dominated resources.

The economics of liquid-dominated resource development have also been enhanced by energy investment tax credits and by the "avoided cost" pricing provisions of the Public Utility Regulatory Policies Act of 1978 (PURPA). The PURPA provisions permit the sale of geothermal electric energy to a utility at a price equivalent to the marginal cost that the utility would otherwise incur for generating this electricity from other sources. These economic incentives are particularly influential to the development of moderate (300F to 400F) temperature resources which, because of the direct relationship between resource temperature and energy conversion efficiency, are more costly to develop than high (>400F)

temperature resources. As illustrated in Figure 2 (from Wright, et al. 1980), roughly 4 times as many geothermal resources are estimated to be in the moderate temperature range than in the high temperature range. Inducements for the development of these moderate temperature resources, therefore, are likely to noticeably affect development at roughly 80% of the known and projected geothermal resources in the United States (ref. Cassel, et al. 1981).

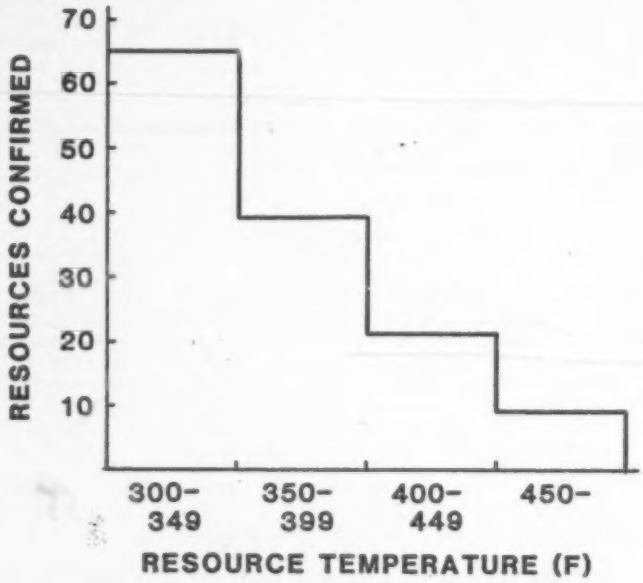

Figure 2. TEMPERATURE DISTRIBUTION OF POSTULATED GEOTHERMAL RESOURCES BY THE YEAR 2000

The national outlook for geothermal electric power development in the years past 1985 is largely speculative at present. This is due, in part, to: (a) the relatively short, 3-year planning and construction lead time for geothermal power plants; and (b) an understandable "wait and see" attitude on the part of utilities and developers which affects commitments at liquid-dominated resources until many of the initial proof-of-concept facilities listed in Table 1 are demonstrated. Only at The Geysers are there currently announced commitments to add generating capacity in the 1985-1990 time frame. 477 MWe of new capacity are currently committed during this period at The Geysers and, at present, there are speculations of at least another 371 MWe (ref. telephone survey in January 1982).

All of the known and projected geothermal power development in the United States between now and the year 2000 will occur within the area of the Western System Coordinating Council (WSCC) -- an electric utility group which encompasses the Northwest Power Pool Area, the Rocky Mountain Power Area, the Arizona-New Mexico Power Area, and the California-Nevada Power Area. Recent load growth projections for the WSCC indicate that electric energy demands are expected to grow at an annual compound rate of 4.1 percent through 1990 for the western system as a whole (WSCC, 1979). To meet these demands, utilities in the WSCC have announced a net increase in

installed generation capacity of 50,600 megawatts between 1980 and 1990. Of this planned increase, 90 percent is baseload capacity including some 13,400 megawatts of nuclear additions, 7,900 megawatts of conventional hydro additions, 23,600 megawatts of coal-fired additions and 2,200 megawatts of geothermal additions.

Although only 4 percent of the planned increase is presently slated as geothermal power, the baseload qualities of geothermal generation render it a suitable candidate for a much greater fraction of the 50,600 megawatt increase. If economically feasible, geothermal generation could, for example, supplant some of the planned nuclear and coal-fired additions. This may be desirable because, as noted in the WSCC reliability study, "nuclear and coal-fired baseload units are highly susceptible to delays...and substantial or sustained delays in these installations can be expected to have serious consequences on the adequacy of the region's bulk power supply". The relatively short construction lead times and minimal environmental impact of geothermal plants offer an attractive planning option.

Two recent and independent assessments of geothermal electric power potential concur that, at best, about 5,000 megawatts of economic geothermal generation could be installed by 1990 at known and projected resource discoveries (Kruger and Roberts, 1980, and Cassel, et al. 1981). This upside potential is less than 10 percent of the baseload additions required by western electric utilities within the same time frame. These figures: (a) demonstrate that optimistic geothermal supply projections are significantly less than baseload demand projections in western regions; and (b) support an assumption that within the foreseeable future there will be no constraint on geothermal power demand attributable to utility system capacity requirements. There are likely to be constraints attributable to geothermal resource supply, relative generation economics and technical feasibility. However, if these criteria are satisfied, a demand for geothermal power does, and will, exist.

A special Task Force effort was organized by the Department of Energy in 1980 to project the development of geothermal power through the year 2000. Working with this Task Force were qualified geothermal advocates, potential market representatives and independent consultants including Technecon. Objectivity was pursued throughout the exercise. The Task Force estimated that a geothermal resource base capable of supporting 30,000 to 40,000 MWe of power generating capacity will likely have been discovered, though not developed, in the United States by the year 2000. The extent to which this upside potential will have been commercially developed by the year 2000 was then estimated by the use of statistically-sound forecasting methods which have been developed by Technecon over the past 5 years and which are supported by the results of: (a) executive interviews with more than 80 individuals in the geothermal and electric utility industries; and (b) demonstrated field practice to date.

The forecasting methodology involves the combined use of two modern techniques from the decision sciences, namely "multiattribute utility analysis" and "logit choice estimation" (ref. Blair, Cassel & Edelstein, 1982). This methodology analytically compares time-wise geothermal investment opportunities to other investment opportunities available to resource developers and electric utilities. From the resource developers' point of view, comparisons are made in terms of rate of return, duration of investment exposure, expected present value of profits, amount of capital at risk, and the probability of project failure. From the electric utilities' point of view, comparisons are made in terms of: electric energy production cost (mills/kWh) delivered to a main

transmission corridor, expected plant availability, net plant output, and risk to corporate or municipal bond rating. A computerized multiobjective analysis then provides estimates, over time, of the joint likelihood of investments by resource companies to develop well fields and by electric utilities to construct on-site geothermal power plants and transmission facilities.

The objective here is to efficiently estimate the outcome of an industrial investment decision based upon an investment analysis that is considerably less rigorous than that employed in the actual industrial decision process. Whereas the industrial decision-maker considers a multitude of attributes when weighing the risks and returns of an investment opportunity, it is possible to predict the numerical likelihood of a positive decision -- within an acceptable confidence interval -- by employing econometric methods that require significantly fewer investment attributes in a somewhat less rigorous analysis. Although the investment analysis methodology used here is necessarily abbreviated from that used in the actual industrial decision process, many elements of analysis are common to both approaches. In particular, cash flow elements for both the well field and the power plant have been developed in considerable detail from industry sources and empirical field data. The accounting methods incorporated into the cash flows are likewise derived from accepted practices in the resource and electric utility industries.

The first step in projecting geothermal resource development for electric uses involves forecasting future confirmations of resources as "candidates" for development. These future confirmations are added, over time, to an inventory of existing confirmations. Development of this inventory is then projected by using the investment decision model described above. Resource confirmations postulated at 5-year intervals by the Earth Science Laboratory of the University of Utah Research Institute (UURI) in mid-1980 provide the basis for our present projections of geothermal power development (ref. Wright, 1980). UURI defined these resources in terms of expected temperature, well flow rate (with and without pumping), salinity, well cost, and size based upon an extensive analysis of regional geologic and hydrologic data. Figure 2 illustrates the results of UURI's analysis in terms of the temperature distribution of resources which are expected to have been confirmed by the year 2000.

Figure 3 presents the projected development of geothermal electric power between 1985 and 2000. Shaded areas in the figure illustrate the range between pessimistic and optimistic likelihoods of joint investments by resource developers and electric utilities. Projections are provided for two cases: one where government-sponsored programs are discontinued and one where these programs are expanded. These programs include: (a) regulatory streamlining and accelerated leasing; (b) high-risk R&D activities in geosciences, materials, downhole pumps, binary cycle power plants, drilling technology and well stimulation techniques; (c) limited proof-of-concept demonstration plants at new resource discoveries; (d) continued energy investment tax credits; (e) limited loan guarantees; and (f) marginal pricing of geothermal power according to the intent of Section 210 of the Public Utility Regulatory Policies Act of 1978.

The resulting forecast indicates that, with continuing Federal cooperation, development by the year 2000 is expected to be in the range of 13,000 to 17,000 MWe. If Federal programs are terminated, these values fall to a range of 4,000 to 7,000 MWe. Development at The Geysers (included in the above figures) is expected to be affected very little by Federal programs and will likely be in the

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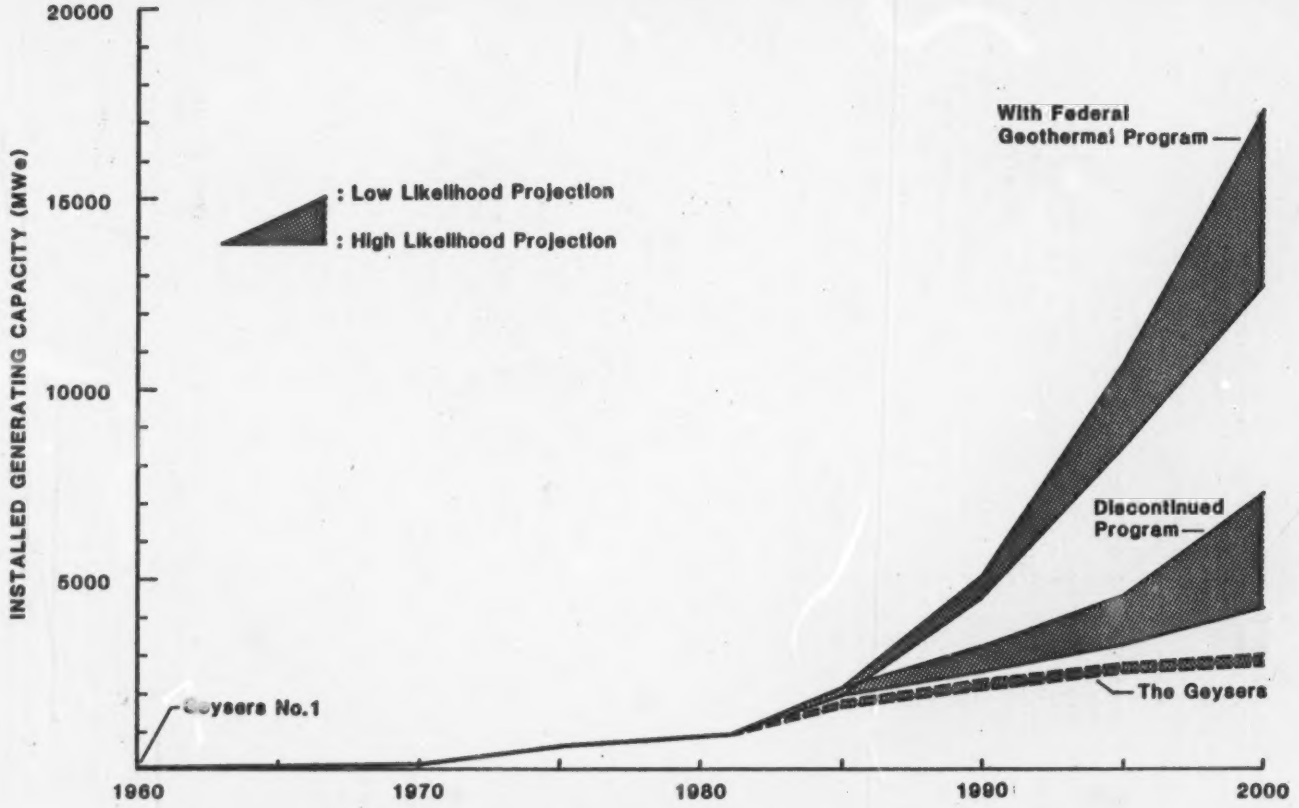

Figure 3. NATIONAL OUTLOOK FOR GEOTHERMAL ELECTRIC POWER DEVELOPMENT

range of 2,500 to 3,000 MWe by the year 2000. Figure 4 illustrates the approximate distribution by states of this projected geothermal power development by the year 2000. The differential level of geothermal power development that can be attributed to Federal programs translates into an energy equivalent of roughly 200,000 to 450,000 bbl/day of crude oil. In a strategic sense, this compares with average imports of 385,000 bbl/day during 1981 from Libyan sources.

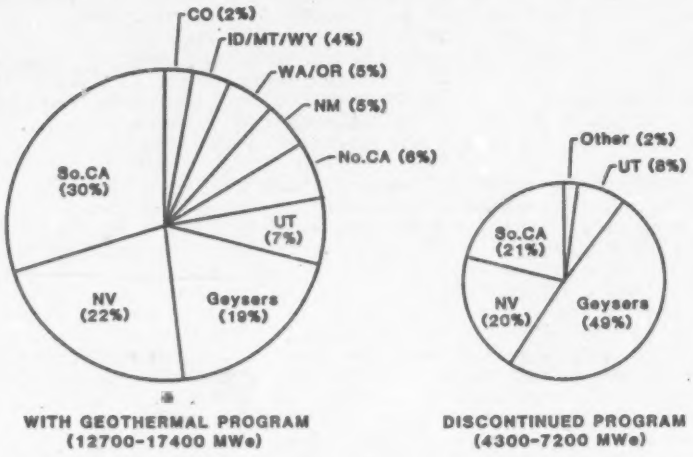

Figure 4. REGIONAL DISTRIBUTION OF GEOTHERMAL POWER DEVELOPMENT AS PROJECTED FOR THE YEAR 2000

The substantial promise of geothermal electric power in the United States is evident from these projections of resource development. Realization of this national promise will now depend, to a large degree, upon the willingness of the geothermal industry to invest capital into research, development and demonstration (R,D&D) facilities at liquid-dominated resources. Such investments at numerous hypersaline and lower temperature (<400F) resources are particularly risky today. As the geothermal industry embarks on this country's first large scale development of technologically challenging liquid-dominated resources, the question of the need for government support must be addressed.

The United States' geothermal resource base is fragmented among hundreds of geothermal leaseholders, a small fraction of which may be classified as "active" developers. Of the few active developers, many are poorly capitalized and lack the financial resources to conduct required R,D&D activities. Those with sufficient capital (typically major oil companies) generally appear disinterested in making substantial geothermal R,D&D investments primarily because: (a) these firms already have substantial sums invested in exploration wells and related expenses; (b) the investments are risky; (c) research results at one resource may not be transferable to the development of another; and (d) because of limited leaseholdings, the potential payoff at a particular resource may be insufficient to warrant risky R,D&D investments. Whereas the aggregate geothermal payoff to the nation in terms of both economic power and displaced energy imports appears substantial, the payoff to individual, active and well-financed developers appears

insufficient to prompt substantial R,D&D investments. A case may be made, therefore, for government funding of high risk R,D&D activities at these liquid-dominated resources.

Government loan guarantees may also be justified, to a limited extent, for some geothermal power projects. In particular, projects that will contribute to a better understanding of liquid-dominated resource utilization (i.e., "proof-of-concept" facilities) would be effective loan guarantee candidates. Such government backing would be useful for the initial development at resources which, were it not for perceived risks related to insufficient production experience, represent attractive and economic investment opportunities. As production experience is accumulated at liquid-dominated resources, commercial resource insurance will likely replace the investment community's need for government-backed loan guarantees. Until such experience is acquired, however, the loan guarantee will serve a limited but useful role.

This country's geothermal resource base holds the promise of supporting several thousands of megawatts of electric power generating capacity. This promise has already been realized at The Geysers, a rare vapor-dominated resource in northern California. The geothermal industry now looks to the more prevalent, but more challenging, liquid-dominated resources for continued development. Although these domestic resources offer an economic source of power, there remain technological uncertainties which translate into investment risk and hinder private sector involvement. Whereas other forms of so-called "alternative" energy sources may require artificial market inducements to accelerate their acceptance, this does not appear to be the case with geothermal resources. The economics of geothermal power are such that subsidies and "commercialization" efforts are unnecessary. What are necessary, however, are effective R,D&D programs to tackle the technological problems of liquid-dominated resource utilization. Government backing of these programs appears warranted in view of their high risk characteristics coupled with their high payoff potential to the nation.

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March 3, 1982

The Honorable Mr. Don Fugua, Chairman
Science & Technology Committee
The House of Representatives
United States Congress
Washington, D. C. 20515

Dear Mr. Fugua:

I am writing to express concern regarding the eroding government support for development of alternate energy sources, and in particular, wind energy. The Administration's FY-83 Budget for wind energy, if implemented, will seriously jeopardize U.S. industry interest in developing this resource and dampen user commitment to this technology. Your support is requested for legislation which will provide a timely transition period for wind energy technology from its present R and D state to widespread industrial use. Every major form of energy now used in this country has had government support during its early introductory phases either directly or indirectly. Wind energy should not be the exception.

The areas needing continued government support are:

(1) Wind resource determination.

The U.S. government should fund programs to establish the amount of wind energy available within the U.S. The best sites for this resource should be specifically identified, and a continuous record made of wind speed levels and directions. This is very similar to the function that the U.S. Geological Survey performs for water resources.

(2) Wind characteristics.

There is a dearth of factual data available regarding the structure of wind streams near the earth's surface; the turbulence patterns; velocity/height variations; effects of local obstructions; etc. This is similar to the function that NASA performed for the aircraft industry in gust research.

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(3) Windmill design.

The major area of uncertainty in windmill design is the structural design of the propellor blades and its dynamic interaction with the supporting tower. A continuing program of R and D in propellor structures, materials, and technology is needed. This is beyond the scope which an individual company will fund, and the information should be available to all of U.S. industry.

(4) Technology demonstration programs.

The translation of a major product from technology into commercial use is a difficult endeavor, particularly, if this translation requires a large financial investment by the private sector. In airplanes, this risk was mitigated by government procurement of military aircraft which demonstrated the feasability of the technology. For synthetic fuels development, the government offers loan guarantees and/or price support. The U.S. windmill industry needs government assistance to stimulate private investment in building large, commercial windmills with long and trouble-free operating lifetimes. DOE's Mod 5 program is important both to the industry for the technology that it will demonstrate and to the investor community as an indicator of technological progress. We don't believe that this demonstration program requires that two competing designs be constructed. One will do. In addition, the manufacturer selected should cost share the design and development of the demonstration installation.

Bendix has not participated in any of the government's demonstration programs in the past and has developed its windmill with private funds. The continued government support of the Mod 5 program is an effective subsidy of our competitors, Boeing and G.E. We do not believe that such subsidies are in the best interests of a free market. However, from the overall national need for development of additional energy sources, the Mod 5 program should be continued but in a modified form; i.e., one contractor, cost sharing provisions, greater participation by all of industry, etc.

(5) Reducing the risk for early owners of large wind energy systems.

The Wind Energy Act of 1981 proposed that government stimulate the early use of wind energy by various incentives for early windmill owners, i.e., cost sharing, etc. There has been no action by the Federal Government to fund such a program. Every effort should be made to get this program underway. The financial community is demanding that the windmill manufacturer warranty his product for longer periods of time than other manufacturers with products having a long background of experience. The manufacturer, however, lacks the financial incentives to assume such a risk. It just is not a good investment risk to take. Therefore, little action results. Government involvement is needed to minimize the early financial risks involved if early, widespread use of the national wind resource is to be achieved.

I welcome this opportunity to express my views and those of my colleagues involved in the wind energy program on this very important matter. We welcome your support.

Very sincerely yours,

Edward Gray

E. Z. Gray

cc:
Mr. Gene Franco

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EDMUND G. BROWN, JR.
GOVERNOR

TESTIMONY OF

ELINOR SCHWARTZ
ASSISTANT DIRECTOR FOR ENERGY

BEFORE THE

ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

My name is Elinor Schwartz. I have represented the California Governor's Office and the California Energy Commission in Washington for more than five years. California has sought to diversify as well as conserve its energy sources. For example, the use of solar energy has expanded with direct financial incentives such as the 55 percent solar tax credit and utility solar financing demonstration. The Energy Commission has promoted passive solar designs through its building standards and has provided technical assistance to local governments preparing their own solar ordinances and establishing their municipal solar utilities. The Commission has funded direct heat geothermal projects as well as demonstrations of agricultural waste products for process heat. The Commission has also performed resource assessments and evaluated hydroelectric, wind, and cogeneration technologies as well.

The State has pledged its resources to further the creation of energy options that reduce vulnerability. It cannot do this job alone. It looks to the federal government to continue its traditional role in research and development, one that has been far more balanced than the technological favoritism shown in the President's proposed budget this year.

This statement will focus only on five areas under the subcommittee's jurisdiction, urging continued federal support for (1) the Heber Binary Geothermal Project; (2) the Salton Sea Solar Pond Powerplant; (3) the SMUD Photovoltaic Project; (4) the Geothermal Loan Guarantee Program; and (5) the Barstow Solar Central Receiver. Additional material on the Salton Sea project has been attached.

HEBER BINARY GEOTHERMAL PROJECT

Completion of the Heber binary geothermal project has been a major California R&D objective throughout the many years of consistent Congressional support. There is good reason. This 50 megawatt (65 MW gross input) plant will be the first commercial scale binary facility using liquid dominated resources. It is expected to open the way to development of moderate temperature resources, which account for 80 percent of the

hydrothermal reservoirs. In California alone, according to Geological Survey Circular 790, there are enough geothermal resources in the 150° to 210° C temperature range to produce over 3500 megawatts of electricity.

The consequences of terminating federal funding for the project, as suggested in the President's budget, would be (1) the loss of previously committed federal funds ($19 million, which would be paid back during commercial phase); (2) the loss of previously committed private funds, the source of more than half of the project costs; and (3) the lack of commercial scale operating experience for utility decision makers, which could result in the delayed use of moderate temperature geothermal resources or continued use of a technology without the environmental and cost advantages of a closed heat exchange system that returns brine to its reservoir. The importance of this project has even increased with the abandonment of the New Mexico flash demonstration late last year.

The California Department of Water Resources is taking an equity position in the project, which is budgeted for $2 million. The consortium, headed by San Diego Gas and Electric Company, includes the Electric Power Research Institute, the Imperial Irrigation District, the California Department of Water Resources, and Southern California Edison. Construction is expected to start this year. The purchase of major pieces of equipment, including the turbine, have been delayed for weeks or months pending DOE approval. Major equipment together with detailed engineering expenditures would amount to $23 million in FY 83. The consortium and other developers of hydrothermal resources are beyond the philosophical arguments about commercialization. They look to this Committee for its continuing leadership and support for binary technology.

SALTON SEA SOLAR POND

Recognizing that this is not a propitious time to raise a new project with the Committee, it is still important to note when ongoing research of wide applicability has reached the stage appropriate for starting a pilot plant. This is the case of the Salton Sea Solar Pond 5 megawatt project in Southern California. The purpose of this project would be to obtain hands-on experience in the design, construction, and operation of a solar salt pond generating facility that would serve as the foundation for design and construction of a 600 megawatt commercial generating facility at the Salton Sea. It would also establish a technical basis for the application of this technology as an energy source for applications in other parts of the country.

The unique energy storage feature of the solar pond enables it to produce power both day and night during any season of the year. Stratified layers are created that trap solar heat in the highly salty bottom layer, while the next higher layer acts as an insulator. Convection is reduced by floating nets on the top layer. Hot brine (about 200°F) is piped from the bottom through heat exchangers to vaporize a working fluid, which drives a turbine generator combination. The vapor is then condensed by cool water piped from the upper layers of the pond. All three fluids are recycled. The salt concentrations are maintained by adding concentrated brine at the bottom and by washing the surface with less saline water from the adjacent main pond.

The Department of Energy (DOE) has been an active partner in the preliminary studies that have resulted in highly positive technological feasibility and environmental assessments. DOE is now funding 50% of the preliminary engineering and cost optimization study, the California Energy Commission and Southern California Edison are each funding 25% of the $1.3 million study. Joint funding of the pilot plant is proposed on the same basis, with the Jet Propulsion Laboratory serving as General Project Manager.

Aside from minor funding for preconstruction water clarity and soils work possible under the Administration's proposed budget, another $2 million is needed as the federal share of the project in order for construction to begin on schedule in FY 83. A total of $23 million of federal funding (as spent) would be allocated over four years. About five years of testing at the Naval Parachute Test Range site would provide the information necessary to scale up the project to commercial size at the next order of magnitude.

Although solar pond technology has been studied for over 20 years, it has only recently become feasible to apply it to large scale energy production. The first experimental ponds were developed in Israel, at the Dead Sea. Ormat's research pond completed there in December 1979 has produced 150 kilowatts of electricity. Ormat is now developing its own 5 megawatt facility. Much can be learned from this ongoing experience. However, the Dead Sea brine concentration is almost another order of magnitude, 280,000 ppm versus 37,000 ppm at the Salton Sea. A different set of issues is involved at the Salton Sea in determining methods of accelerating brine concentrations, while maintaining the brine in solution. Hydraulic and thermodynamic behavior management of thermally stratified ponds is the key to commercial development. Methods for maintaining water clarity and suppressing waves also need to be improved along with instrumentation and controls.

A commercial scale facility at the Salton Sea with a thirty year life could be privately constructed at the cost of about $1800 per kilowatt of installed capacity (1980 dollars), which is comparable to coal-fired or nuclear generating systems. Pond technology is attractive not only for its low operating cost, but also for its environmentally benign nature. In fact, a side effect of this facility would be a reduction in Salton Sea salinity, which is threatening the existence of many of the species inhabiting it, because of 4 million metric tons of salt received each year.

Clusters of 20 to 50 megawatt commercial scale modules could provide 600 megawatts at the Salton Sea alone. In the year 2000, potentially 580 million barrels of oil could be displaced per year from electrical production by solar ponds in the Southwest, Salt Lake, Gulf Coast, and Red River areas. A minimum of 920 million barrels of oil per year could be displaced in direct heating uses by solar ponds in those areas plus in the Black Hills, Pacific Northwest, Atlantic Northeast, Great Lakes, and Tennessee Valley. With the exception of Alaska, solar ponds could provide thermal energy at sufficiently high temperatures for space and water heating of building clusters in all regions of the U.S. Solar ponds could also lend their thermal, mechanical, or electrical energy applications to desalinization and a variety of agricultural uses, such as irrigation pumping, crop drying and space conditioning.

SMUD PHOTOVOLTAIC PROJECT

The Commission also urges federal support for the second megawatt of the 100 megawatt Sacramento Municipal Utility District Photovoltaic Project. The $7 million requested will enable the next set of bids to take place in FY 83. This front-end support will enable the project to get underway while the cost of photovoltaics exceeds that of alternate generation technology. The federal government is to be repaid for taking this risk later in the project's development. The State Energy Commission budget contains a $2 million contribution to the first megawatt, helping to match the $68 million in federal funds for FY 82. This project will be the largest central station photovoltaic project and will provide a major boost to the industry. The project will also provide an opportunity to perfect fabrication and construction techniques as well as to optimize efficiency and safety under high voltage conditions.

GEOTHERMAL LOAN GUARANTEE

The California Energy Commission has been encouraged by this Committee's continued support for the Geothermal Loan Guarantee. The Commission would oppose the Administration's arbitrary termination of new commitments at the end of FY 82, if any of the presently available guarantee authority had not been obligated. It is too early in the development of this industry to foreclose opportunities to small independent companies that are initially dependent on venture capital for both capital and operating costs. Although they may have considerable technical expertise, they may not be in a position to pledge the assets that a major corporation could. Because of their cash flow positions, they are not in a position to sit on leases, waiting for alternate fuel price increases to bid up the value of their resources.

It would be appropriate to leave open the option for any of the $364 million in currently uncommitted funds that remain in FY 83 to be used for follow-on support for powerplants at developed fields or for projects that might not have been ripe before the application deadline. The Energy Commission's contributions to geothermal resource development have included the streamlining of powerplant certification, resource assessments, and environmental studies.

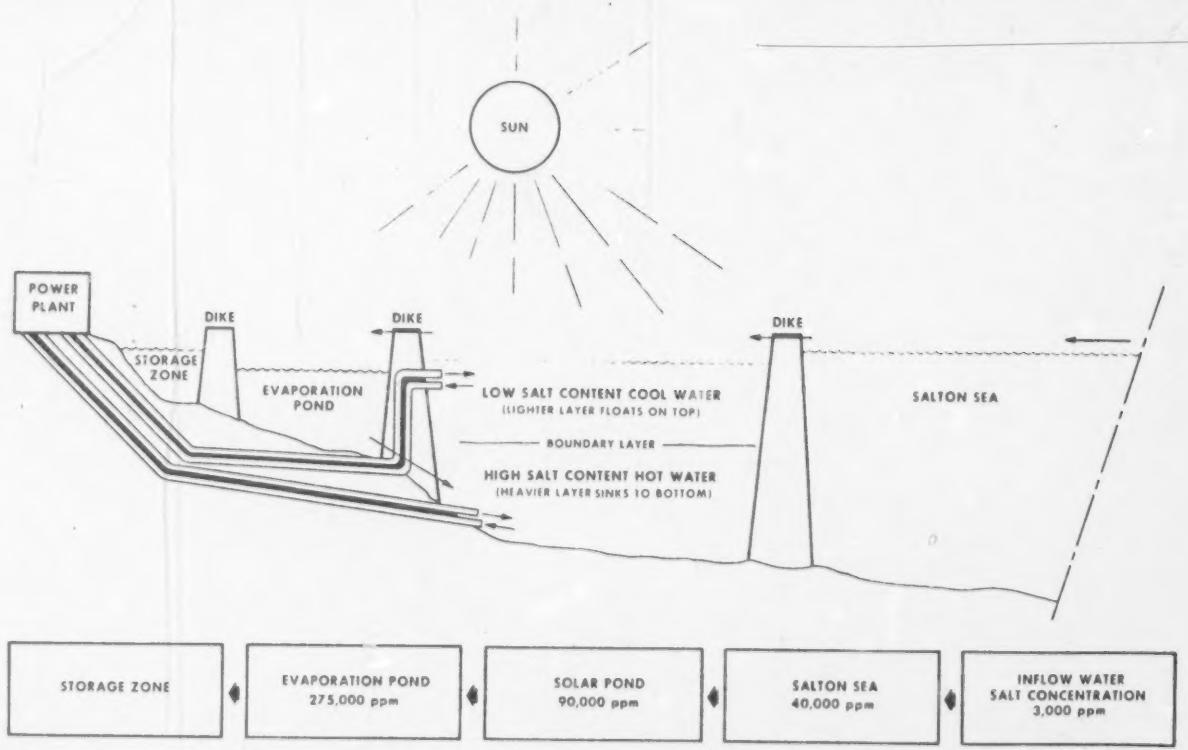
BARSTOW SOLAR THERMAL CENTRAL RECEIVER

The 10 megawatt Barstow Solar Thermal Electric project is nearing completion. The system is scheduled to begin operating in Barstow, California by this summer, following a set of tests mandated by the Department of Energy. These tests will include calibrating the movement of sun-tracking mirrors (heliostats) that concentrate solar radiation to heat steam that, in turn, drives a turbine to produce electricity.

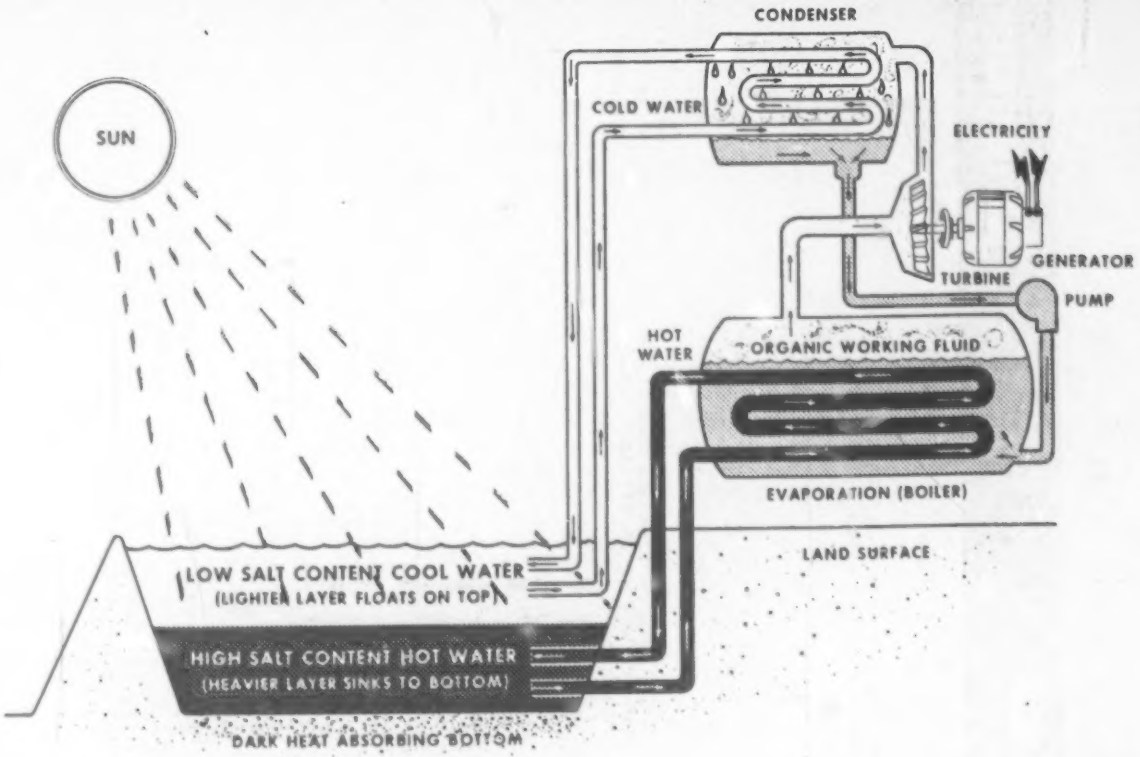
This pilot is the largest solar thermal project in the U.S. In addition to gaining essential operation and field experience, this project will help determine the costs of solar thermal electricity at various rated capacities in order to maximize cost effectiveness. This information will be directly useful to the 100 megawatt solar thermal project being considered by the lead member of the consortium, Southern California Edison, as well as to additional hundreds of megawatts in longer term plants of other utilities. The State Energy Commission has contributed $50,000 to the environmental impact report for the project.

DESIGN CHARACTERISTICS OF 5MW SOLAR SALT POND POWER PLANT

Gross Power Output	5000 KW
Net Power Output	4000 KW
Load Factor	.7 (5800 hr/year)
Power Module Heat Input	178 MBtu/hr
Power Conversion System Efficiency	9.6%
Overall Plant Thermal Efficiency	2.2%
Hot Brine Flow Rate	44,000 gpm
Hot Brine Temperature	185°F
Hot Brine Specific Gravity	1.22
Cooling Water Source	Salton Sea
Cooling Water Flow Rate	44,000 gpm
Cooling Water Temperature	73°F
Organic Working Fluid Flow Rate	800 lb/sec
Turbine Inlet Pressure	133 psi
Turbine Outlet Pressure	37 psi
Solar Pond Area	60 Acres
Pond Depth	16.5 feet
o Thermal Storage Zone	11.5 feet
o Nonconvective Zone (Insulation Layer)	4.25 feet
o Upper Mix Layer (Convective Layer)	.75 feet



Salton Sea commercial solar pond concept



Solar pond generating concept

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▶ CONGRESSMAN DON FUQUA RPT DLY MGM
CHAIRMAN SUB-COMMITTEE ENERGY DEVELOPMENT & APPLICATIONS U.S. HOUSE REPRESENTATIVES
WASHINGTON DC 20515

SOLAREX CORPORATION, THE WORLD'S LEADER IN THE MANUFACTURE AND SALES OF PHOTOVOLTAIC SYSTEMS, STRONGLY OBJECTS TO THE SEIA TESTIMONY OF MARCH 16, 1982, AS NOT BEING REPRESENTATIVE OF THE VIEWS OF THE PHOTOVOLTAIC INDUSTRY.

SOLAREX DOES NOT BELIEVE THAT "SUBSTANTIAL REDUCTION IN THE COST OF SOLAR SALES SYSTEMS...REQUIRES THE DISCOVERY OF POTENTIALLY LOW-COST MATERIAL". THIS IMPLIES THAT SILICON CELLS PARTICULARLY THE SEMI-CRYSTALLINE PANELS DEVELOPED, PATENTED AND MANUFACTURED BY SOLAREX CANNOT ULTIMATELY ACHIEVE THE LOW COSTS NEEDDED FOR WIDE SCALE USE IN THE U.S. THIS IS BLATANTLY WRONG.

IT IS PRECISELY BECAUSE THE SEIA DOES NOT CORRECTLY PORTRAY THE TRUE PHOTOVOLTAIC INDUSTRY VIEW POINTS, BUT TENDS INSTEAD TO BE A REFLECTION OF THE PERSONAL VIEWS OF ITS CHAIRMAN, THAT SOLAREX CORPORATION, THE LEADING PHOTOVOLTAIC MANUFACTURER HAS REFUSED TO JOIN SEIA.

IT WOULD BE COSTLY AND WASTEFUL TO FOLLOW SEIA'S ADVICE AND PLACE THE MAJORITY OF GOVERNMENT FUNDS IN UNPROVEN AND QUESTIONABLE NEW MATERIALS WHEN THE MAJORITY OF THE PHOTOVOLTAIC INDUSTRY IS COMMITTED TO MAKING SILICON CELLS USEFUL FOR U.S. NEEDS.

I BELIEVE THAT THE TECHNOLOGY DEVELOPMENT OF SILICON CELL SYSTEMS IS THE MOST IMPORTANT ELEMENT THAT SHOULD BE MAINTAINED IN THE PHOTOVOLTAIC PROGRAM.

JOSEPH LINDMAYER PRESIDENT SOLAREX CORP
1335 PICCARD DR
ROCKVILLE MD 20850

12:44 EST

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MAR 29 1982
COMMITTEE ON SCIENCE AND TECHNOLOGY